

England's Rare Mosses & Liverworts



Their history, ecology and conservation



Ron D. Porley

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Published by Princeton University Press,
41 William Street, Princeton, New Jersey 08540
In the United Kingdom: Princeton University Press, 6 Oxford Street,
Woodstock, Oxfordshire OX20 1TW
nathist.press.princeton.edu

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Project managed by Dr Jill Sutcliffe
Edited by Jill Sutcliffe, Andy Swash and Gill Swash

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British Library Cataloging-in-Publication Data is available

Library of Congress Control Number 2012956134
ISBN 978-0-691-15871-6

Production and design by **WILD**Guides Ltd., Old Basing, Hampshire UK.
Printed in Singapore

WILDGuides wishes to acknowledge the financial support of Natural England.

10 9 8 7 6 5 4 3 2 1

COVER: *Fissidens serrulatus*, a Mediterranean–Atlantic moss of shady riverbanks known from
two localities in Cornwall and Devon. Photo: Ron Porley.

FRONTISPICE: The Vulnerable dioicous liverwort *Solenostoma caespitium* with male (*right*) and
female (5-winged perianths) plants. Photo: Štěpán Koval (Czech Republic).

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Introduction

Man is placed in the middle between two infinities – the infinitely great and the infinitely small – both of which are incomprehensible to him.

Edinburgh Encyclopaedia

This is a book about mosses and liverworts, collectively known as bryophytes, a term derived from ancient Greek and first used around 1878. Britain is currently home to 1,044 species, comprising 752 mosses and 292 liverworts (1,048 if the four British hornworts are included). They are small, relatively simple plants that live on the land (although some have returned to freshwater), and depend upon water for fertilization. They are the earliest known land plants and were thriving on the ancient landmasses of Pangaea and Gondwana-land millions of years before flowering plants made their entrance onto the world's evolutionary stage. As a result of their small stature, they have been able to exploit a diverse range of niches of which many are unavailable to so-called higher or flowering plants. They are supremely adapted to life on earth, not least because of their ability to remain alive for long periods of time without water and yet rapidly recover when wetted with rain or dew.

In England, there are 666 mosses and 252 liverwort species (excluding four hornworts). Some 87 (9%) are on the revised Red List of British bryophytes, a system that estimates the extinction probability if nothing is done to change the situation. A total of 84 species of English threatened bryophytes is profiled in this book, and a further three species have not been seen in England for more than 50 years. But this is not a Red Data Book *per se*. Instead, the emphasis is on understanding rarity, what causes it and the implications for conservation. Rarity is a complex notion, yet we think we know what it means and use the term in everyday conversation. Many bryophytes are naturally rare and flourish, but many more have had rarity thrust upon them by human activities. If conservation can reasonably avert the extinction of a bryophyte, and the understanding gained thus helps safeguard other populations, then morally it is right that we do so. The key to preventing a plant sliding inexorably towards possible extinction is an awareness of what leads to a species becoming rare in the first place. This book brings together the relevant literature to understand what 'rare' means in the context of mosses and liverworts. In doing so the intention is not to elevate the importance of the rare at the expense of the common. Arguably the common species are more important in the wider picture; paradoxically a common species may be more threatened if it occupies an environment that is decreasing or if it has a life-history that depends on the maintenance of large or numerous populations. Bryophyte conservation and recording is not just about the plants; it is about people too, past and present, who have done so much to propel England (and Britain) into the position of one of the best bryologically known countries in the world. Their contributions are acknowledged throughout the book.

England is one of the mostly densely populated countries in Europe, with 395 people per square kilometre, constituting 84% of the total United Kingdom population. The most densely populated areas of England are the major cities and metropolitan areas of London and the South East, South and West Yorkshire, Greater Manchester and Merseyside, the West Midlands and the conurbations

It could be argued that many bryophytes were lost from these areas long ago, and that now the battleground has shifted to areas of the country that have been spared the ravages of the Industrial Age such as the south-west of England (although tin mining had a long and

productive history here and has given rise to important bryophyte habitats) and ostensibly protected areas, for instance the New Forest in Hampshire.

Wales and Scotland (for the latter see Rothero, 2005) also have a fair measure of threatened bryophytes but many of their rare and interesting species occur in more remote and relatively undisturbed habitats; there is greater pressure on lowland habitats and species further south in Britain. No part of Britain is, however, free from the pervasive effects of pollution, nutrient enrichment and climate change. Species action is often funded under UK or European initiatives, and then is normally implemented at the national level. The statutory conservation agency Natural England (NE) is the body tasked with ensuring that biodiversity, including bryophytes, is not eroded in England.

Bryophytes are no respecters of national frontiers. In a phytogeographical context England is part of the British Isles and the wider Atlantic Biogeographic Region which encompasses the UK, Ireland, and the western parts of Denmark, Germany, The Netherlands, northern Belgium, north-west France, the northern shores of Spain and a small area in the north of Portugal. This is a key concept in the EC Habitats Directive, a powerful European Union (EU) instrument, where sites for the protection of habitats listed at Annex I and species listed at Annex II of the Directive are selected in the context of such Regions. Site protection and habitat conservation are vital, if not the most effective mechanism available, to maintain and increase populations of bryophytes. This topic is covered in the section on 'Conservation measures' (*page 19*). The 'listing' of species and habitats is seen by some as an activity that is interminable, sometimes excessive and to the more cynical to keep bureaucrats in a job, but it is genuinely fundamental to any conservation programme. It provides not only an inventory of what species occur in any geographical area but guides the allocation of scarce conservation resources. Furthermore, lists are used extensively in enforcement and legislation, themes also covered in the section on 'Conservation measures' (*page 19*).

The species profiled in this book are English bryophytes drawn from the revised Red List of British bryophytes (Hodgetts, 2011). The Red List uses criteria and categories developed by the International Union for Conservation of Nature (IUCN) to determine which species are most threatened and hence in need of conservation action (see *page 31*). It is possible to apply the IUCN system at any geographical scale, but whether this would be sensible for a land the size of England is debatable. If the IUCN criteria were applied to England alone the list would be quite different. There are many bryophytes that would be regarded as rare in the English context if localities or populations were counted, but just across the border the same species may be frequent or even abundant. The wisdom of channelling finite resources into protecting such species is open to question. England has a very effective network of Wildlife Trusts that focus action at the county level and this is commendable since local extinctions can reverberate wider. Thus, although this book focuses on England's rare and threatened bryophytes derived from the British Red List, it provides pointers to conservation priorities at all levels.

Bryologically, the British Isles is one of the best mapped regions, with 'dot maps' that are envied across the world. Yet at the other end of the scale, at the site level, we are not so good. Conservation often falters because those who implement action on the ground are frequently unaware that a particular species is present. Regrettably, the lack of awareness of what species occurs on which site hinders progress in the conservation of England's bryophytes. It is an uncomfortable truth that simple neglect or the accidental obliteration of a bryophyte through ignorance is also a threat.

The consequences of *over*-collecting in the past cannot be denied and examples of where unrestrained collecting has arguably caused a significant decline of a species are mentioned in the relevant species profiles. Although the bryologist of today is more conservation conscious and acts responsibly, populations of rare bryophytes, even on designated sites, continue to be at risk because their presence is not known or known to only a few. In this book it was judged important to be as transparent as possible about sites where threatened bryophytes are known to occur.

A principal aim of this book is to make this particular group of plants and their conservation needs more accessible to a wider audience, through the eye of many skilled photographers, with images of the mosses and liverworts that in all their diversity are sadly at risk of extinction in England if we allow it to happen. Images are powerful: it is much easier to empathize with the loss of something precious if you have a picture of it in your mind. We are rightly concerned about the plight of the European Lynx. Most people have never seen one in the wild but nevertheless know what a lynx looks like because they have seen pictures of it in books, on the internet or on television. It is not to suggest that *Leiocolea rutheana* or *Timmia megapolitana* will ever be as iconic as charismatic megafauna but at least it is hoped that this book will enable readers to appreciate their beauty and be inspired to care for these and other threatened bryophytes.

The images are almost all digital and have been provided by many people; in terms of provenance most are from Britain (all the habitat pictures are), but several are from Europe and a couple are from North America. A bryophyte from the European mainland, or indeed from across the Atlantic, looks much the same as its English equivalent so the priority has been to select the best picture available to give a true likeness of the species. Photographs of bryophytes growing in the field are used wherever possible but for two species no images could be traced. *Lophozia herzogiana* is depicted by an illustration from Jean Paton's 1999 *British liverwort flora of the British Isles* and *Acaulon mediterraneum* is taken from volume 3 of *Flora Briofítica Ibérica*, 2006.



What are bryophytes and why are they important?

Small is beautiful

A bryophyte is a land plant with enclosed reproductive structures that does not have highly developed vascular tissues (for the internal transport of water and nutrients). Neither does the plant have a flower or produce seeds, reproducing as it does sexually via spores and/or asexually by a range of propagules. Such a definition scarcely does justice to the beauty of these small humble plants that adorn our world. The exquisite lithographic prints by Ernst Haeckel (1904), illustrating the remarkable diversity of form of mosses (*left*) and liverworts speaks to us much more lucidly than words can. Although the term 'bryophyte' is used throughout this book to refer to mosses, liverworts and hornworts as a group, it really refers to a shared structure and way of life rather than a group with a single evolutionary origin; indeed all three groups evolved separately from one another and from other plants albeit from a green algal ancestor (see below).

Mosses are perhaps the most familiar group. Typically they have green leafy shoots, either as upright shoots or straggling over the ground. The leaves are spirally arranged on the stem although on occasions may appear flattened in one plane, and often (but not always) have a nerve or mid-rib down the centre of the leaf. Mosses have traditionally been separated into two main types: acrocarps which are typically erect and mostly unbranched and pleurocarps which are prostrate and highly branched. The spore-producing structure, the sporophyte, is attached to the leafy plant, and the spore-containing capsule is held aloft on a thin stalk (seta) or sometimes inconspicuously hidden amongst leaves. The mouth of the capsule may or may not have a ring of teeth, the peristome, which helps to regulate the release of spores. If a plant has sporophytes it is often referred to as 'fruiting', a throwback to an earlier century when it was thought the moss capsule contained seeds.

Leafy **liverworts** are generally softer plants, with leaves arranged along the sides of a weak stem, and the sporophyte is almost evanescent, comprising a translucent stalk and a dark shiny spherical capsule. Spores are released by rupture of the capsule wall. The thalloid liverworts, lacking leaves, look quite different and appear as tiny rosettes to moderately sized mats of green tissue, sometimes resembling certain lichens. Whilst thallose lichens are usually of a different often paler colour on their underside and are relatively tough, thalloid liverworts are similarly green on both sides and the texture is soft and rather delicate.

Hornworts, the third bryophyte group most closely resemble the thalloid liverworts but have quite different long-lived sporophytes that resemble tapering horns, splitting along their length to release the spores. None of the four British species of hornworts are currently on the revised British Red List although one, *Phaeoceros carolinianus*, was previously considered Endangered but recent survey has found no evidence of a decline and it has been downgraded to Near Threatened. Therefore, hornworts are not considered further in this book.

There are many other morphological differences (as well as similarities) between the three lineages of bryophytes, and the reader should consult other works for more detail on this topic (see Porley & Hodgetts, 2005; Schofield, 1985; Vanderpoorten & Goffinet, 2009).

Alternation of generations

A common feature amongst the bryophytes is the phenomena known as alternation of generations, discovered by Hofmeister in 1851. This life cycle, where a dominant haploid branched gametophyte (the green leafy plant) alternates with a diploid unbranched sporophyte (the spore producing structure) is unique in living land plants. In most other land plants the gametophyte is extremely small; in ferns it is the free-living structure called the prothallus (which is often mistaken for a thalloid liverwort in the field!). By contrast, in flowering plants and conifers the gametophyte is reduced to just a few cells (embryo sac and pollen) and is enclosed within the much larger dominant sporophyte phase (for example, the oak tree or the rose plant).

In bryophytes the transition from haploid (the gametophyte with one complete set of chromosomes) to the diploid state (the sporophyte with two complete sets of chromosomes) is brought about by fusion of egg and spermatozoid. The switch back from diploid to haploid is mediated by meiosis, and leads to spore formation. The spore, with one set of chromosomes, ultimately gives rise to the green plant (gametophyte) we recognize as the moss, liverwort or hornwort and its cells divide and multiply by the process of mitosis. Such a life cycle has predestined bryophytes to a life dependent upon water for a motile spermatozoid (or sperm) to effect fertilization of the egg (some recent work however has suggested sperm dispersal may also be assisted by micro-arthropods such as mites (Cronberg, Natcheva & Hedlund, 2006).

The earliest land plants

The advent of land plants is one of the most important events in the Earth's history. It changed global climates and biochemical processes and set the stage for the evolution of all eukaryotic (organism whose cells contain complex structures enclosed within membranes) terrestrial life on Earth. The first plants that colonized land were probably plants at a bryophyte level of organisation, most likely a liverwort. Thus bryophytes represent the earliest of the land plants. Various strands of evidence indicate that green algae are the ancient forebears of bryophytes and, by implication, all other land plants and that colonization of the land began on the eastern shores of the ancient landmass Gondwana as long ago as the early Palaeozoic, some 543–248 million years ago (Rubinstein *et al.*, 2010).

It is difficult to be precise when the first true liverwort, moss or hornwort appeared due to uncertainties in interpreting the fossil record. Astonishingly, a compression fossil found in China dating from the Cambrian Period (about 500 million years ago) is thought to be a possible moss, morphologically close to the extant genus *Funaria*. Nonetheless, by the close of the Palaeozoic era, the main bryophyte evolutionary lines were established. To put this into context, bryophytes were on the Earth some 264 million years *before* the arrival of flowering plants. Today, the flowering plants are the most diverse plant group on the Earth with an estimated 250–300,000 species occurring worldwide. Bryophytes are the second most diverse plant group, at just over 16,000 kinds known to science, yet it has been suggested that the true total may be around 22,000 (Chapman, 2009). A recent estimate of world liverwort species is given as 7,500 (von Konrat *et al.*, 2010). The number of molecular studies at the population level in liverworts and mosses is currently limited and thus we have little appreciation of the scale that 'cryptic' species contribute to bryophyte biodiversity; existing studies suggest a significant part of bryophyte biodiversity is undetected with traditional morphological concepts alone (Heinrichs *et al.*, 2009).

Small yet successful

Fundamental to understanding why bryophytes have survived for so long and are so successful is their adoption of the poikilohydric life-style, which means their ability to dry out, suspend metabolism and then resume physiological activity when water becomes available, a key step in their evolutionary development. Despite their apparent delicate and fragile appearance bryophytes can withstand extreme changes in water availability. Their water content is directly regulated by the ambient moisture and they are capable of absorbing water over the whole surface of the plant, aided by a multitude of shoot and leaf adaptations (including papillae, lamellae and tomentum) designed to exploit surface tension phenomena. A moss such as *Grimmia* growing on an exposed rock surface can dry out completely and enter a kind of dormancy, then rapidly resume physiological activity come the first raindrops or overnight dewfall. They can do this with no degradation of cell organelles or membrane disruption by virtue of possessing a set of protective proteins, the accumulation of soluble sugars, and metabolic repair mechanisms. Even bryophytes of typically moist environments such as cloud forest can tolerate days of drought more than most flowering plants could survive. Nevertheless, there is great variation in the extent of desiccation that different species of bryophyte can tolerate.

Bryophytes have remained small throughout their evolution chiefly because they have not evolved lignin, a substance giving other land plants rigidity that enables them to grow tall in their struggle to reach the light. It seems that desiccation tolerance is an adaptive strategy for bryophytes *because* they are small (Proctor *et al.*, 2007) and one that has enabled bryophytes to grow in places and under conditions denied to other land plants. It is because bryophytes are so closely tied to the external environment that they represent excellent indicators of climate change (Tuba, Slack & Stark, 2011).

Importance and uses of bryophytes

The ecological importance of bryophytes is belied by their small size. They contribute to a substantial proportion of the global plant biomass in a range of ecosystems, in particular peat bogs, other wetland vegetation and forest systems. They play a major role in carbon and nutrient recycling as they are net sinks of carbon dioxide, particularly in the northern peatlands, regulate water availability by acting as slow release sponges in many forest systems, may promote soil formation facilitating the establishment of other plants, stabilize and protect soils against wind and water erosion, and mediate soil temperature and moisture. On account of these attributes, together with sensitivity to pollution, bryophytes are extensively used as biological indicators in both terrestrial and aquatic environments. Countless invertebrates use them for shelter and egg-laying sites, yet direct consumption by animals is limited owing to a armoury of protective secondary compounds discouraging herbivory.

An excellent review of the uses of bryophytes is provided by Glime (2007). It would be misleading to suggest bryophytes have an economic importance approaching that of flowering plants but they do have their moments. Peatlands, dominated by *Sphagnum* moss, are the source of peat for horticulture, a particularly environmentally damaging but lucrative industry for which alternatives are now being found. Living *Sphagnum* because of its high absorbency and inherent antibacterial properties was also used as a wound dressing during various wars, including World War I, and was collected in large quantities (see *next page*) from Scotland and England. Today it is used for nappies, cleaning up oil spills and filtering



Large quantities of *Sphagnum* moss were collected during the First World War for use as field dressings. Men and women are filling sacks on the bleak hills of Dumfriesshire. (Reproduced by permission of D. Forman).

of industrial and domestic effluents, uses that exploit its superior absorbent properties. Other mosses are increasingly being investigated for waste water treatment and recycling in a range of situations. In Britain, large pleurocarpous mosses were harvested and sold to florists as moisture retentive medium for bulbs. For example, up to the 1970s at Lakenheath in the Brecklands of East Anglia, *Pleurozium schreberi* was raked out of the turf and stuffed into sacks for just this purpose.

One of the earliest documented medicinal uses of bryophytes is in a 16th century *Chinese Compendium for Materia Medica*, and bryophytes are still used in Chinese and native North American's folk medicine today. Increasingly bryophytes are being screened by the pharmacological industry for antibacterial and anticancer activity, and researchers are particularly interested in bryophyte genes that code for desiccation tolerance and substituting these into commercial crop varieties such as tobacco. Various mosses also have an application in construction, such as insulation and fire proofing, still practised to this day in some parts of the world, and more mundane uses including doormats and brooms (using *Polytrichum*). Bryophytes have long been used in various fields of scientific endeavour but have come of age for the evolutionary window that they can provide on understanding land plant development. The genome of *Aphanorrhagma* (*Physcomitrella*) *patens*, a common moss in Britain, was sequenced by an international consortium and published in 2008. The genome is estimated to contain approximately 35,000 genes, or 486 million base pairs, more, surprisingly, than revealed in the sequence of the flowering plant thale cress (*Arabidopsis*) (Cumming, 2011). With regard to genetic engineering, mammalian genes transferred into the moss genome of *Aphanorrhagma* have resulted in the production of mammalian proteins and, in the future, may offer promise for the large scale manufacture of therapeutic proteins such as insulin.

The aesthetic beauty and spiritual fulfilment to be gained from an appreciation of mosses is well known to the Japanese. Moss gardens have existed in Japan since the 14th century; many of them associated with the grounds of Zen Buddhist temples imparting an ambience of great serenity and peace to those who tread within. This reminds us that we do not always need to exploit nature for it to have a value and it is not there simply for our gratification. Bryophytes have a place in this world, if only for their own sake. And we do have a moral obligation to ensure they continue to enrich the world and inspire us.

Rarity in bryophytes

The pressure of a steadily increasing human population on the biodiversity of the planet is an all too familiar theme, bringing with it habitat loss and fragmentation, modification (including the spread of invasive species), over exploitation, pollution and climate change. Closer to home the natural environment in England is much less rich now than 50 years ago (NE, 2008). The global, regional and local decline in rare (and common) bryophytes can, in part, be attributed to these factors.

But what is a rare bryophyte? In practice this a difficult question to answer. The first thing to recognize is that of the 1,048 (922 in England) bryophytes known to occur in the British Isles most can be considered as 'rare'. Rabinowitz (1981) proposed what has become the most widely cited classification of rarity. In this scheme, a species is classed as rare if it fits just one of the following criteria: a narrow or highly disjunct geographical range, high habitat specificity, or a consistently low population size. Analysis of the British flora by Birks *et al.* (1998) showed that whilst the majority of species have a large geographical range, about 79% of liverworts and 77% of mosses have high habitat specificity and 80% of liverworts and 81% of mosses have a consistently low population size. This is in line with our knowledge of the biological world in general: that most of the world's plants and animals are rare in some sense of the word (Kunin & Gaston, 1993).

Distribution is just one way of viewing rarity; evolutionary history and genetic variation are equally valid approaches and are, of course, interrelated. This issue is considered in some detail in the section on 'Conservation measures' (page 19). In this section, we look at some of the biological characteristics of bryophytes that may lead to them being rare, habitat dynamics, and distinguish natural rarity from human-induced rarity.

Reproductive biology and rarity

To understand at least some of the reasons for rarity in bryophytes we need to consider their reproductive biology. Bryophytes are able to reproduce sexually, producing spores by meiosis following fusion of male and female gametes, or asexually which essentially bypasses any mixing of genetic information (spores and asexual propagules are known collectively as diaspores). Sexual reproduction enables dispersal (via spores) in both time and space and introduces genetic variation, crucial aspects for survival. Spores may be small enough to be carried in wind currents although the actual distance depends on many factors. Spore production may not occur for a number of reasons (including failure to produce antheridia or archegonia) and those species that do not produce spores are significantly rarer than those that do. Finally there is 'clonal reproduction', a form of asexual reproduction, where the disintegration by decay of protonema, stems and other structures leads to separate

The aesthetic beauty and spiritual fulfilment to be gained from an appreciation of mosses is well known to the Japanese. Moss gardens have existed in Japan since the 14th century; many of them associated with the grounds of Zen Buddhist temples imparting an ambience of great serenity and peace to those who tread within. This reminds us that we do not always need to exploit nature for it to have a value and it is not there simply for our gratification. Bryophytes have a place in this world, if only for their own sake. And we do have a moral obligation to ensure they continue to enrich the world and inspire us.

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fragments that can multiply and contribute to the maintenance of the population (Frey & Kürschner, 2011).

Mosses and liverworts have either *separate* male and female shoots (the dioicous state, about 56% of British mosses and 68% liverworts) or the male and female organs (gametangia) are on the *same* shoot (the monoicous state, about 44% of British mosses and 32% liverworts). The monoicous state is traditionally further subdivided depending on the relative position of gametangia on the shoot. About a dozen bryophytes, mostly liverworts, may show both states. In dioicous species, for spore production to occur the male and female shoots must be close enough to facilitate gamete (sperm) transfer and fertilization, typically a few centimetres or less. As a result, a much higher proportion of dioicous bryophytes fail to produce sporophytes (the capsule or spore producing organ). By contrast, monoicous species have the potential of self-fertilization. In the British Isles monoicous mosses are, perhaps unexpectedly, significantly rarer than dioicous species although this pattern is not seen in liverworts. Within the rare monoicous group, mosses and liverworts show differences in terms of sporophyte production; in mosses most species produce sporophytes freely but many rare monoicous liverworts are not known to produce sporophytes at all.

Analysis of the sexuality and rarity in the British bryophyte flora (Longton, 1992; Laaka-Lindberg, Hedderston & Longton, 2000) has shown that most rare bryophytes are either dioicous species that fail to produce sporophytes or monoicous species that commonly produce sporophytes. This suggests that dioicous species become rare because of the failure to produce sporophytes, which limits either their dispersal potential (ability to spread to suitable habitat) or their genetic variation (they become 'less fit' and are thus less able to respond to environmental change). If low genetic diversity could be demonstrated as a causal factor of rarity in dioicous species an effective conservation strategy may be achieved by reciprocal transplantation between male and female populations. Experimental studies have shown that suitable habitat patches may remain unoccupied or 'empty', demonstrating that dispersal related factors is the likely explanation for rarity at least in some bryophytes (Söderström & Herben, 1997).

In monoicous bryophytes, those that fail to produce sporophytes for whatever reason may also suffer the same constraints but, since monoicous bryophytes are more likely to be rare than dioicous species, another explanation is needed. In this case, where the plant is rare but commonly produces sporophytes, one explanation may be that self-fertilization occurs leading to reduced genetic variability and thus the ability to adapt to changing environmental conditions is compromised – although there are currently no data to support this hypothesis.

Asexual reproduction

Many British bryophytes, about 46% of liverworts and 17% of mosses, produce some kind of asexual propagule (Laaka-Lindberg, Korpelainen & Pohjamo, 2003). Specialized asexual propagules, such as gemmae, bulbils and tubers (see *pages 16–17*) probably serve mainly as a means of local persistence and enable rapid colonization when conditions become favourable. All bryophytes can potentially regenerate from fragments of leaves, shoots and other parts; this is known as 'totipotency', the ability of a single cell to divide and produce all the differentiated cells in the organism. Dispersal and regeneration of bryophyte fragments is thought to occur quite widely in nature. This mode of dispersal has been little studied in British bryophytes, although regeneration could not be experimentally induced in the Red Listed *Tortula cernua* (*page 183*) using leaf fragments (Headley, 2006). We need to

understand better the part played by asexual reproduction in maintaining populations of species that theoretically lack longer distance dispersal capacity. Production of asexual propagules does not seem to have any significant correlation with rarity in mosses or liverworts, although there is an association with spore size and sexuality (see below).

Since specialized asexual propagules are relatively large (compared to spores) it is believed that they are poorly adapted for wind dispersal and, instead, play a role in short distance dispersal (typically in the order of centimetres) and thus are important in maintaining local populations. Most British liverworts that can produce asexual propagules do so much of the time and production is independent of sexuality. Liverworts that produce neither asexual propagules nor spores are the group most likely to be rare. By contrast, dioicous mosses produce asexual propagules much more frequently than monoicous species, and frequent asexual reproduction is found more often than expected among mosses for which sporophytes are unknown and less often in species with sporophytes, particularly so in dioicous species. Production of asexual propagules also shows a strong link to the colonist group of dioicous mosses (see life-history strategies section below).

There is also evidence that asexual reproduction is related to spore size (Söderström & During, 2005). Small-spored species tend to produce asexual propagules more often than expected compared to large-spored species (in general, small spores are $\leq 25\mu\text{m}$; large spores are $\geq 25\mu\text{m}$). This trend was not evident for monoicous mosses. Furthermore, in dioicous mosses small spore size is correlated with a short lifespan, while in monoicous mosses species with short-lived shoots and big spores tend to be in the majority.

Life-history strategies

The concept of life-history strategies (During, 1992) recognizes different groups of bryophytes based on reproductive effort, spore size and lifespan and how they can survive in a changing environment through a number of 'trade-offs'. A species may invest resources and effort into producing a few large spores, which may have a greater chance of establishment and survival but may not disperse very far, or many small spores that may be able to disperse large distances but may have a reduced establishment and survival probability, or the potential lifespan of the bryophyte may be negatively correlated with reproductive effort. The strategies include perennial stayers that are characteristic of stable habitats and short- and long-lived shuttle species and colonists which typically grow in cyclical temporary habitats. Some bryophytes are capable of exploiting more than one life-history according to their habitat and the prevailing conditions. There is a tendency for colonists and perennials to be dioicous (*Thamnobryum angustifolium* (page 175) is a good example of a dioicous perennial moss in which sporophytes are unknown), while annual and short-lived shuttle species are mainly monoicous.

Colonists comprise about 51% of the total British moss flora overall (Longton & Hedderson, 2000), and are typical of habitats available for short periods of time such as arable land. They assure continuity of the population by, for example, the development of tubers on underground rhizoids. Analyses of threatened British bryophytes (Hodgetts, 1996) showed that most short-lived shuttle species were classified as Endangered or Critically Endangered, with relatively few classified as Vulnerable, whilst most perennial stayers are Vulnerable (see section on 'The Red List' (page 31) for an explanation of these terms). The high representation of colonists and shuttle species amongst the threatened species has implications for their conservation since these require regular disturbance of the habitat in

Spindle-shaped gemmae borne on shoot tips (pseudopodia) of the moss
Aulacomnium palustre. Photo: BBS (Iceland).



Disc-shaped gemmae in half-moon gemmae cups on the thalloid liverwort
Lunularia cruciata. Photo: Ron Porley.



Tiny many-celled bulbils in the axils of the upper leaves of *Pohlia bulbifera*. Photo: Des Callaghan.



Tubers on the rhizoids of *Bryum klinggraeffii*, a common arable field moss. Photo: Rachel Carter.

order to provide favourable conditions. A final word of caution: the analysis of the British bryophyte flora life-history strategies needs much more study. The life-history adopted by an individual for survival is likely influenced by many factors and it will vary across the geographic range of a species; as yet, the allocation of a species to a particular life-history group is often based on theoretical assumptions rather than on direct field data.

Habitat dynamics and rarity

Globally, bryophytes show both broad and highly disjunct distribution patterns. For the last 50 years or so, the approach has been to explain this by the separation of the early supercontinent Pangaea into the southern supercontinent Gondwana and the northern supercontinent Laurasia, which began some 200 million years ago. Bryophytes were rafted far and wide on the fragments and came to rest as the tectonic plates repositioned themselves – the continental drift theory. This may explain many of the broad distribution patterns, but overlain on this is long-distance dispersal by wind. This has long been invoked as a mechanism for dispersal of bryophytes but until recently there had been little experimental support (Muñoz *et al.*, 2004). It is suggested that subsequent regional population extinctions have given rise to some of the disjunct distributions of bryophytes we see today, a view attracting growing support following recent studies based at the molecular level.

There is evidence from palaeoecological studies of fossil bryophytes from the late-glacial/post-glacial transition that mosses and liverworts responded rapidly to major environmental changes (Birks, Heegaard, Birks & Jongsdard, 1998), and that they could migrate and colonize newly created habitats with remarkable speed. Wind the clock forward to the present day

amid a modern landscape and it seems reasonable to suggest that there are significant constraints on the ability of bryophytes to effectively disperse and find optimal habitat. Data on fragmentation and habitat losses in England have been presented elsewhere (NE, 2008), and only the general principles of habitat dynamics as they relate to bryophyte populations are discussed here.

Metapopulation dynamics and fragmentation

The survival of a bryophyte depends not only on population dynamics within small parcels of habitat known as habitat patches, but on the dynamics between the habitat patches – the so-called metapopulation dynamics. This essentially states that immigration and extinction between patches must be in balance for a species to survive, yet this interplay is determined by the ability of the bryophyte to disperse and the nature of the landscape. If the distance between habitat patches is too large, or barriers too great to overcome, dispersal between them may be reduced or not occur at all. Alternatively, the habitat may be available for a short time only, and the dispersal may be too slow to happen relative to the duration of the patch.

Habitat parameters, including size, quality, spatial and temporal distribution and number of patches, have been much less studied than population dynamics but one of the clearest changes in the modern landscape is that of habitat fragmentation. The resulting decrease in the area of habitats ultimately leads to a decrease in local populations and an increased risk of local extinction; total diaspore production decreases and, most critically, the distance between habitat patches increase such that dispersal distances are greater than before. Indeed, the regional scale distributions of bryophytes are usually limited by habitat dynamics and rather less by population dynamics, a view supported by bryophyte population dynamics models, which show that dispersal limitation occurs only when the mean among-patch distance and the variation in establishment probability are high (Söderström & Herben, 1997). Expressed another way, models demonstrate that if a species is able to survive at all, it has the potential to colonize almost all available patches (*i.e.* it is habitat limited), whereas if the species is dispersal limited the mean/average distances between habitat patches increase (Söderström, 1998). Additional evidence from actual field studies also suggests that habitat availability may be more important than a plant's dispersal ability as a cause of *natural* rarity in bryophytes (Laaka-Lindberg, Hedderson & Longton, 2000).

Niche breadth is an important concept in bryology. It is based upon the premise that rare species utilise a relatively narrow range of resources, whilst more common species are able to use a broader range of resources and consequently occur in more places. An analysis of the bryophyte flora of Lancashire by Callaghan & Ashton (2008) demonstrated support for this concept and showed that two indicators of niche breadth, the range of habitats and substrates occupied by a species, are positively correlated with range-size. In other words, they showed that rare species occupy a significantly narrower range of habitat and substrate than more common species, both at the scale of the study area (Lancashire) and of the British Isles. Whilst this may be linked to dispersal ability of a species, habitat factors such as fragmentation and quality of patches are also important. Low occupation of apparently suitable sites has been observed by several workers and it seems that tolerances in bryophytes to habitat and substrates are related to initial establishment requirements (Söderström, 2005; Cleavitt, 2002; 2005) which are only poorly understood.

Returning briefly to the concept of life-history strategies, perennial species with large between-years fluctuations in colonization ability are affected less than short-lived species that need to recolonize frequently. Impaired reproduction may occur for a number of reasons, such as pollution and a species may be able to sit tight for as long as the habitat patch remains suitable. Shuttle species where within-patch dynamics is important are less affected than perennials or colonists and are most affected by a decrease in patch size. Metapopulation models predict that short-lived species with low dispersal ability will be most at risk from habitat fragmentation (Söderström, 1998); as noted earlier many of the Red Listed bryophytes in Britain have such a strategy.

Natural and human-induced rarity

This section has endeavoured to collate some of the inter-related factors that cause a bryophyte to be rare, including reproductive biology, life-history strategies and habitat dynamics. It seems that although habitat limitation would intuitively appear to be the cause of rarity in bryophytes, current evidence points to *dispersal limitation* as the cause of occurrence at few localities. Human pressure on the land has probably been responsible for this situation and it is likely to intensify as fragmentation and exploitation of habitats continue (Söderström & During, 2005). Callaghan & Ashton (2008) and Söderström & During (*op cit*) have put forward the view that most *naturally* rare bryophytes are habitat limited (narrow niche breadth) and able to survive as small but stable populations provided dispersal ability at least balances the local extinction rate. Such species have always been rare and probably always will be, and not all are necessarily threatened. For most declining bryophytes, the focus of this book, dispersal limitation would seem to be the reason for rarity. As the population size of a bryophyte decreases due to erosion of habitat patches – and fragmentation increases – there is a concomitant decrease in diaspore output, with the result that dispersal to available and ever more distant suitable habitat patches is compromised. It is this group of bryophytes that is threatened and represents *human-induced* rarity.

Conservation measures

Today ‘conservation’ is a well-worn term and is used in many contexts. Protection, guardianship, restoration, preservation and management are just a few of the words used to define it. This section aims to show how nature conservation is delivered in the wider sense and how *bryophyte* conservation impacts on the bryophyte flora of England. Conservation needs to operate at a number of complementary levels if it is to be effective. The two foremost measures to protect bryophytes in England are through habitat conservation (including habitat management, restoration or enhancement) and species conservation implemented through Action Plans or similar. Other valuable complementary approaches are *ex situ* conservation (such as off site in a botanic garden or similar) and translocation, for example moving or reintroducing a threatened bryophyte and thus reinforcing a diminished population. These actions are undertaken within a framework of processes and mechanisms and will be briefly considered in this section (for a discussion of bryophyte conservation activities in Europe see Porley *et al.* 2008).

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Habitat conservation

England's bryophytes can only continue to exist if there is adequate quality habitat and good connectivity between patches, attributes shown to be important in the preceding discussion on rarity. Furthermore, bryophytes will be better equipped to deal with climate change impact and pollution events. Without exception, studies of the biology of rare bryophytes are united by one conclusion: that effort should be directed towards maintaining the largest possible areas of natural and semi-natural vegetation – in other words the habitat (Longton & Hedderson, 2000; Bisang & Hedenas, 2000; Cleavitt, 2005). This holds true for both common and rare species and for conserving genetic diversity.

Sites

Arguably, most of the high-quality habitat in England is contained within the Sites of Special Scientific Interest (SSSI) network. The Nature Conservancy Council (NCC), under the National Parks and Access to the Countryside Act 1949, began the selection and notification of SSSIs, latterly taken forward by English Nature (*EN*) under the Wildlife and Countryside Act 1981 (WCA 1981) with some notification being undertaken by the current statutory agency Natural England (*NE*). Bryophytes were invariably not part of the SSSI selection procedure in the early days of notification, but many were included *de facto*. There are some 4,114 SSSIs in England covering a total of 1,076,986 ha, or 8% of the total area of England (*NE*, 2008). The majority of SSSIs are small, with 40% less than 10 ha and 82% smaller than 100 ha. National Nature Reserves (NNR) – the jewels in the crown – of which there are 221 in England, cover an area of about 95,776 ha, although virtually all NNRs are also SSSIs. NNRs tend to be larger, with 56% being at least 100 ha or more in size. International site designations, such as those originating in the EU under the Habitats and Birds Directives that have been designated as Special Areas of Conservation (SACs) or Special Protection Areas (SPAs) respectively (collectively known as the Natura 2000 site network), plus the Ramsar wetland sites, cover some 884,623 ha of England, of which virtually all are also notified as SSSIs. Of the total semi-natural habitat in England, only about 48% lies within SSSIs. A large proportion of non-SSSI land is, however, contained within other designated areas such as National Parks (NP) and Areas of Outstanding Natural Beauty (AONB) and these alone cover 23% of England.

A preliminary investigation of the overlap of modelled and projected future climatically suitable regions for rare bryophytes within the current SSSI network was carried out by Anderson & Ohlemüller (2011). The proportion of hectare (10 × 10 km squares) records of rare bryophytes within 100 m of an SSSI was calculated and was shown to be low for Britain as a whole. It was particularly low for England, with half of the species having at least 62% of their hectare records within 100 m of an SSSI boundary¹. The results also indicated that there are regions where rare bryophytes may be inadequately protected since there is not always an overlap between distribution of bryophyte records and SSSIs. For example, there is a high concentration of SSSIs in parts of N and W Yorkshire but few hectare records of rare bryophytes, whereas to the east of this area there are many bryophyte records but few SSSIs. There are areas of congruence; the New Forest in southern England is a good example. There could be many reasons to account for these observations and more field data with precise species coordinates is required. The results of the study therefore need to

¹ for Wales it was 75%, for Scotland 79%

be interpreted with caution but they do suggest that the current SSSI network is insufficient to safeguard English rare bryophytes from the effects of climate change.

It is well known that some species in other groups, such as orchids, are more or less confined to protected sites and this is certainly the case for many bryophytes as shown in the species profiles in this book. Monitoring work has shown that in groups characterized by very specific habitat requirements (such as birds, butterflies and bees) there has been a steep decline in individuals and populations (NE, 2008). Many bryophytes, as pointed out earlier, also have high habitat specificity and a narrow niche breadth and are thus likely to be under similar pressures.

Species conservation

Ultimately, nature conservation comes down to species – the plants and animals that share our world. It is essential to know which species are threatened and, provided that the reasons why are understood, conservation measures can be taken. For the majority of bryophytes, habitat conservation is inseparable from species conservation and may be the only measure needed. But for some bryophytes, actions which are specifically tailored to the needs of an individual population may also be necessary to address the decline.

Species conservation operates through several processes and mechanisms. In the early days of statutory nature conservation in England, bryophytes were given scant attention and protection was largely incidental to that of either the habitat or other species groups. The seminal *A Nature Conservation Review* (Ratcliffe, 1977) may well have kindled the first stirrings of organised bryophyte conservation in England. This two-volume work recognized the importance of mosses and liverworts and included bryophyte lists in accounts of major biotopes and sites. Although the statutory conservation community was slow to take up the cause of bryophytes, the British Bryological Society (BBS) was acutely aware of the threats many bryophytes were facing and played an important role in persuading others to take bryophyte conservation seriously.

SSSIs were not selected for their bryophyte interest until 1992, when selection guidelines were published (Hodgetts, 1992) in which species were ranked and scored according to a suite of established criteria. Hereafter a site could be designated on bryophyte interest alone. Where such a species or habitat is chosen, it is termed a notified feature, or a species could be part of the reason for designation alongside other species groups or the habitat. These guidelines have not kept pace with our knowledge of bryophyte distributions nor their current status based on IUCN criteria and are in urgent need of updating. The data are not available giving the number of English SSSIs with *bryophytes* specifically as a notified feature, but the number of SSSIs in which non-vascular plants (bryophytes, lichens, algae etc.) are included as a notified feature is 184 (NE, 2008). An estimate would be that very few sites, probably six at the most (and all in Cornwall), are notified for their bryophyte interest alone. Every SSSI is assessed on a six-year cycle using the Site Condition Monitoring framework developed by the Joint Nature Conservation Committee (JNCC) in association with the statutory agencies. Whilst a Public Service Agreement (PSA) target to achieve 95% of SSSI area in favourable or recovering condition by 2010 was achieved, it does not tell us how bryophytes are faring on those SSSIs. It has been acknowledged that better surveillance of bryophytes is needed in England's natural environment (NE, 2008).

UK Biodiversity Action Plans (BAP)

What was to be perhaps the most significant advance in bryophyte conservation came when the UK government signed up to the first global agreement, the Convention on Biological Diversity (CBD), at the 1992 Rio Earth Summit. Two years later the UK Biodiversity Action Plan (UK BAP) was published, the UK government's response to the CBD, containing six moss and five liverwort Action Plans. By 1999, there was a total of 35 moss Action Plans and 11 liverwort Action Plans. It is these plans that have so effectively focused action on English bryophytes and their value is evident in many of the species profiles in this book. Following a two-year review of the UK BAP programme starting in 2005, a new bryophyte list based largely on the previous Red List (Church *et al.*, 2001) was published in 2007, and this effectively more than doubled the number of bryophytes on the UK BAP (111 in total, 77 in England). Regrettably, due to resource constraints, many species Action Plans have not yet been written (although JNCC has produced species statements) and there has been variable progress on those that have been published.

The UK BAP review was used as the basis for *NE* to draw up the list of species and habitats of principal importance in England under Section 41 (S41) of the Natural Environment and Rural Communities (NERC) Act 2006. The 77 bryophytes herein are considered to be of principal importance for the purpose of conserving biodiversity in England and, in essence, the Secretary of State (and organisations with the corresponding Public Duty) must take such steps as appear reasonably practicable to further the conservation of the species (and habitats) on the list and promote others taking such steps. Since the S41 bryophyte list was drawn up prior to the publication of the revised Red List of British bryophytes (Hodgetts, 2011) there is currently a mis-match between the two lists. There are 18 species on S41 that are not on the Red List; most of these are currently classified as Near Threatened and include species such as *Dendrocryphaea lamyana*, *Habrodon perpusillus*, *Leptodontium gemmascens* and *Petalophyllum ralfsii*. On the other hand, some 27 Red List species are not on S41, including *Anomodon attenuatus*, *Didymodon cordatus*, *Nardia insecta* and *Tomentypnum nitens*. Of the 87 British Red List species in England, 61 are on the UK BAP list.

Legislation

Special protection is conferred on 37 British bryophytes listed on Schedule 8 under Section 13 of the WCA 1981. The list includes six liverworts and 17 mosses that occur in England, one species (*Bartramia stricta* (see *Appendix 1*)) that is extinct in England, and two species (*Bryum mamillatum* and *B. neodamense*) that have since been synonymized with other species. The benefit of listing on Schedule 8 has long been debated since there was little confidence that the regulations would be enforced, but few would deny that it fulfilled an important role in raising the profile of rare bryophytes and facilitated the protection of the sites on which they occur. The 1992 selection guidelines for lower plants states that a site should be considered for SSSI notification if it supports a viable population of a Schedule 8 plant, and indeed was often used in the justification for notifying a site on its bryophyte interest alone. The bryophytes listed on Schedule 8 have been subsumed, unrevised, into new legislation including the Countryside and Rights of Way (CROW) Act 2000 and, most recently, in Part 2 of the Natural Environment and Rural Communities (NERC) Act 2006.

Regardless of the perceived weaknesses of Schedule 8, there seems more willingness to take legal action concerning the 77 English UK BAP priority bryophytes. In 2003, the first occupier prosecution under the CROW Act 2000 was brought by *EN* for significant damage to rare bryophytes. The incident concerned the West Cornwall Bryophytes SSSI in which the occupier

damaged a disused mine site supporting three UK BAP bryophytes, the moss *Scopelophila cataractae* and the liverworts *Cephaloziella integerrima* and *C. nicholsonii*. The occupier was fined £3,000 with £10,000 costs and ordered to restore the land and monitor recovery.

International legislation

The Bern Convention (1979) also heralded a significant development in European bryophyte conservation. This was the first time bryophytes (26) had been included in an international convention, and it was ratified by the UK government in 1982. However, the real gain occurred when the Bern Convention list was adopted as the basis for the Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (known as the EC Habitats Directive), an enforceable and powerful piece of EU legislation. This requires EU member states to propose SACs (see *page 20*) within defined Biogeographical Regions for the species (and habitats) listed and to maintain or restore the favourable conservation status of the species (or habitat).

Currently, there are 32 bryophytes listed on the Directive, of which four occur in England:

<i>Bruchia vogesiaca</i>	<i>Hamatocaulis vernicosus</i>	<i>Marsupella profunda</i>	<i>Petalophyllum ralfsii</i>
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For two of the English species, *Hamatocaulis vernicosus* and *Petalophyllum ralfsii*, the conservation status is regarded as favourable (classified as Lower Risk) with large populations in a number of SACs occurring in the British Isles, and action requires six-yearly monitoring to assure that optimal status is maintained. *H. vernicosus* was removed from the revised British Red List in recognition of its secure position, and *Petalophyllum* was never Red Listed in Britain as it is known from at least 25 localities in the UK, including some substantial populations in SW England. *Marsupella profunda* is a ‘priority’ species, recognizing that the UK has a special responsibility for its conservation (see *page 127*) (its world range includes England, Portugal, Madeira and Azores), and *Bruchia vogesiaca* is globally rare and known from one site in England (see *page 58*). Both are on the revised British Red List.

The Global Plant Strategy

In 2002, the parties to the CBD approved the Global Strategy for Plant Conservation (GSPC) aimed at slowing the current and continuing loss of plant biodiversity. This initiative was designed to parallel that of the EU Birds Directive. In particular, it included 16 outcome-oriented targets with measurable goals to be achieved by 2010. Regrettably, not all the global and EU targets were achieved but, despite this, governments and conservationists welcomed the first eight years of the Strategy as a success. Progress regarding stemming the loss of biodiversity was reviewed at a CBD meeting in Nagoya in October 2010, and an amended and updated GSPC was endorsed by the world’s governments backed by Members of the European Parliament (MEPs) in Brussels. It aims to ensure a continued global political framework for the work of the IUCN in plant conservation until 2020, including updated global targets against which governments will be obliged to report. Target 1 of the GSPC involves documenting plant diversity, recognizing that a working list of known plant species is fundamental to any plant conservation programme. In Europe, this target was achieved for bryophytes with the publication of a European moss checklist (Hill *et al.*, 2006) but has not yet been achieved for any other plant group; it is crucial to the compilation of European and national Red Lists. Two other targets and their relevance to bryophyte conservation in England are discussed on the following pages.

Important Plant Areas (IPAs)

Target 5 of the updated GSPC stipulates that there should be protection of 75% of the most important areas for plant diversity. Substantial progress towards this target has been made in countries that already have a network of protected sites, and there is inevitably an overlap between existing protected sites and proposed Important Plant Areas (IPAs). For example, the Isle of Portland and the New Forest in southern England have long been regarded as outstanding localities for rare and notable bryophytes and both are notified as SSSIs. In a report to *EN* (Hodgetts, 2007), both sites scored particularly highly in an exercise designed to identify important bryophyte SSSIs. Other high-scoring bryophyte sites to emerge from the analysis included extensive areas of upland, large coastal sites and oceanic woodland. A few old mine workings, supporting a suite of heavy-metal tolerant species, also scored highly. IUCN and Plantlife International are leading a consortium of partners to identify global IPAs for bryophytes.

An IPA should exhibit exceptional botanical richness and /or support an outstanding assemblage of rare, threatened and/or endemic plant species and/or vegetation of high botanic value. Coincidence mapping (see page 36) of the English bryophytes on the revised Red List of British bryophytes clearly shows that SW England (Cornwall and S Devon) and SE England (E Sussex including the Weald and part of Surrey) harbour particularly high concentrations of threatened species. Based on the recorded presence in 10×10 km grid squares (hectads) Preston, Harrower & Hill (2011) devised a classification of British and Irish liverworts and hornworts which resulted in ten recognizable geographical patterns or groups (although most groups are nested within at least one other group). One of these, the *Phaeoceros laevis* group, correlates remarkably well with the SW cluster (which includes mosses too) identified in the current work. Significantly, they also found a high proportion of the liverworts (36%) in the group are threatened.

Although much of the high quality habitat in England is designated, 52% of semi-natural habitat remains outside the SSSI network (NE, 2008). Mapping techniques can be used to identify areas of high bryophyte interest that may lie outside protected sites. For example, coincidence mapping of species such as *Adelanthus decipiens*, *Plagiochila heterophylla* and *Radula aquilegia*, amongst others, may hint at Atlantic woodland fragments and bryophyte-rich ravine sites in which important populations of these bryophytes persist.

The international importance of the Atlantic bryophyte flora in the British Isles has long been recognized (Herzog, 1926; Ratcliffe, 1968, Porley & Hodgetts, 2005). Whilst the Atlantic seaboard of Scotland and Ireland are home to some of the most rich and extensive examples, the celebrated Borrowdale Woods (within the Lodore–Troutdale Woods SSSI) in the English Lake District is also justifiably famous for its Atlantic flora. Many of the Atlantic bryophytes (*sensu* Ratcliffe, 1968), including the three species mentioned above are not rare or currently threatened in the British Isles (but a significant proportion are rare in England), and therefore are not on the revised Red List of British bryophytes or the UK BAP list. IPAs can play an important role in highlighting and protecting non-SSSI sites supporting an Atlantic bryophyte flora.

Several Atlantic species show remarkable disjunctions of range, recurring again in the Himalayan region and Pacific North America. When viewed at the European or even global scale, the Atlantic woodlands and the individual species are of international importance and, for that reason, the British Isles has special responsibility for their conservation. This may become more pertinent in the face of climate change; modelling has predicted that the filmy

fern *Hymenophyllum wilsonii* will show a marked displacement northwards in response to global warming. Since this filmy fern typically shares distributions and ecologies with many Atlantic bryophytes, it is reasonable to suggest that Atlantic bryophytes may be likewise affected (Birks *et al.*, 1998). Arguably the Atlantic flora is of greater conservation priority than many species on the revised Red List and efforts to ensure all localities are identified and protected need to be intensified.

***Ex situ* conservation and recovery**

Ex situ conservation (as opposed to *in situ*) essentially means conserving species away from their natural habitat, usually meaning in the botanic garden or in the laboratory using *in vitro* or cryo-techniques. Article 9 of the CBD (1992) refers to *ex situ* conservation, recognizing its importance as complementary to *in situ* conservation and requires each Member State to establish and maintain *ex situ* facilities. This is echoed in Target 8 of the new GPSC, which advocates that 75% of threatened plant species should be incorporated into accessible *ex situ* collections, preferably in the country of origin, and 20% of them included in recovery and restoration programmes. In 2000, the UK conservation agencies, in partnership with the Royal Botanic Gardens Kew (RBGK), established a pioneering *ex situ* threatened bryophyte project (Ramsay & Burch, 2001), the first of its kind in the world. The current *ex situ* project at Kew was secure up to the end of 2012 and discussions between partners are currently underway to explore future options; meanwhile species acquisitions to the project continue on an *ad hoc* basis. *Ex situ* techniques offer a number of benefits:

- Provide a basal storage collection of bryophyte germplasm representing the genetic diversity of threatened species as a defence against extinction in the wild.
- Provide bulked up material for translocation trials and recovery programmes minimizing sampling from wild populations.
- Provide uncontaminated bryophyte DNA for genetic studies.
- Provide material for education and autoecological research.

An important element of the project has been to develop effective and replicable techniques for the initiation of *in vitro* bryophyte cultures and basal storage using cryopreservation (where material is rapidly cooled to -196°C). A number of novel research papers were subsequently published (Burch & Wilkinson, 2002; Burch, 2003; Rowntree, 2006). There are currently 18 rare British bryophytes in the *ex situ* collection at RBGK, 14 of which occur in England (although not all are Red List species). There is widespread recognition of the success of the *ex situ* bryophyte work at Kew, which has prompted calls to extend the project to embrace not only threatened British species but also globally endangered bryophytes (Hallingbäck & Tan, 2010).

Rare, scarce or threatened English bryophytes in the *ex situ* facility at Royal Botanic Gardens Kew

<i>Aplodon wormskioldii</i>	<i>Ditrichum plumbicola</i>	<i>Rhynchostegium rotundifolium</i>
<i>Bryum calophyllum</i>	<i>Ditrichum subulatum</i>	<i>Seligeria carniolica</i>
<i>Bryum warneum</i>	<i>Jamesoniella undulifolia</i>	<i>Splachnum vasculosum</i>
<i>Cyclodictyon laetevirens</i>	<i>Leptodontium gemmascens</i>	<i>Tortula cernua</i>
<i>Didymodon glaucus</i>	<i>Micromitrium tenerum</i>	<i>Weissia levierii</i>
<i>Ditrichum cornubicum</i>	<i>Orthodontium gracile</i>	<i>Weissia multicaularis</i>

The ultimate *raison d'être* of an *ex situ* collection is to provide insurance against the possible loss of the species in the wild. This implies that the material may be reintroduced back into the wild as part of a recovery programme. The IUCN (1995) has recognized that species translocations have a valuable role to play in recovery programmes and has developed a number of criteria against which a translocation must be evaluated. Any *ex situ* work including translocation is discussed under the relevant species profile.

Conservation of genetic variation

Molecular data are transforming the ways in which we see the biological world and fundamentally it has implications for what we conserve. DNA from the cell nucleus can be used to reveal relationships that are often obscure when simply using morphological or anatomical studies. For example, there is evidence that *Ditrichum*, traditionally placed in the Dicranales, is closer to members of the Pottiales, and *Seligeria*, also conventionally seen as belonging in the Dicranales, shows a very close relationship to members of Grimmeriales (La Farge *et al.*, 2000). Perhaps most intriguing is *Pleurozia purpurea*, a conspicuous reddish-purple liverwort locally frequent in west Scotland and Ireland but not known from England or Wales. Traditionally regarded as a leafy-liverwort and placed in the Jungermanniales, DNA evidence has shown it to be closer to thalloid liverworts in the order Metzgeriales.

Furthermore, DNA studies also raise questions about the concept of species and instead give a picture of continuous variation that arise through isolation or exchange of genetic material with varying frequencies. Our anthropogenic view of the world seems to insist on distinct morphological units that can be recognized and named, but by adhering to this somewhat dogmatic approach critical genetic information may be disregarded or, at worst, lost (for a non-technical discussion see Hedenäs, 2009). Studies have suggested that there is more genetic information within a single common and variable widespread 'species' than there is in rarer 'species' with very narrow distribution ranges (including endemic species) (Longton & Hedderson, 2000; Bisang & Hedenäs, 2000).

In a climate of scarce resources, whether the conservation community is ready to accept the argument that in some situations it is wiser to protect populations of widespread species, rather than rare species, is an intriguing philosophical question. Bisang & Hedenäs (*op cit*) hold the view that resources would be better spent on applying the criteria of 'phylogenetic representativeness' (taxa that represent the total genetic variation in a group), and that we already have the data enabling this to be done at the level of genus for a large proportion of bryophytes. In the meantime, maintaining existing habitat and breaking down dispersal barriers by reversing fragmentation should at least conserve as many bryophyte populations, and hence genetic variation, as possible.

People and bryophyte conservation

The conservation of England's bryophytes could not happen without the involvement of many people at all levels and in many disciplines, from statutory conservation agencies to Non Governmental Organisations (NGOs), Government departments, universities and research institutions, specialist plant societies and last, but not least, the individual. There must be cooperation and a free flow of information between all the players if the threats to the English bryophyte flora are to be managed and minimized. Similarly, it is vital that the

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scientists who describe new species, or split or lump existing ones or tinker with the names, ensure that this information reaches those who generate the species lists for sites where conservation action is focused. In the other direction, it is essential that the species lists produced by field specialists reach the people who drive action forward, typically through the BAP process, and influence those who determine policy. In the British conservation culture this is often (but not exclusively) the statutory conservation agencies and if there is a vacuum or a lack of leadership here, progress may be minimal.

Beginnings

Involvement by amateurs is deeply entrenched in British plant recording and bryology is no exception. The amateur can make exciting discoveries and field recording is the bastion of the bryological societies. The tradition of publishing new records using the British and Irish vice-county system, and seeing these in print, is a powerful incentive to search for rare or overlooked species. It is true that many of the pioneers of British and English bryology were professional or privileged in some way. The so-called father of British bryology, John Jacob Dillenius (1684–1747) was the first Sherardian Professor of Botany at Oxford and he collected bryophytes in various parts of Britain, including England. William Wilson (1799–1871) was also in an enviable position of being able to give up a professional career (solicitor), ostensibly for health reasons, to spend his life in pursuit of his love of nature, in particular bryology. He is today regarded as one of the greatest ever contributors to British bryology.

However, there were also the less privileged bryologists too. Perhaps John Nowell (1802–1867) most epitomizes the ordinary working-class bryologist who gained recognition from his illustrious peers. He earned a hard living as a hand-loom weaver but his spare time, such as it was, was spent tramping the Lancashire countryside searching for bryophytes, only later wandering further afield when the advent of cheap rail travel allowed. In 1896, the Moss Exchange Club (MEC) was formed, comprising mostly amateurs with a few professionals. Its aims were to assist members in building up collections of correctly named specimens and to accumulate valuable distributional data, which ultimately led to the publication of a series of Census Catalogues of British mosses and liverworts, a tradition continued today. Amateur involvement in English bryology continued throughout the 20th century with such luminaries as William Nicholson (1866–1945) and Hugh Dixon (1861–1944); these, and many other workers that followed, have provided a crucial snapshot of the status of the English bryophyte flora just before the all-pervasive land changes that occurred following World War II. For more information on past bryologists and their contribution to bryology see Porley & Hodgetts (2005) and a fascinating series of articles by Mark Lawley on-line at www.britishbryologicalsociety.org.uk.

From the perspective of the late 20th/early 21st century bryologist, one of the aims of the MEC was to assist members in building up a collection of correctly named specimens, a practice that is now rightly frowned upon or condemned. However, this activity took place during a time when the English countryside seemed rich and bountiful in nature, before modern agriculture, forestry and development wrought rapid and irreversible changes to the landscape. Even so, back in 1896 the Victorian bryologist H. N. Dixon cautioned that exchanges of specimens might tend towards the extinction of our rarer species (Richards, 1983). The wholesale collection of specimens was abandoned long ago by the successor to the MEC, the British Bryological Society (BBS), and, although collecting is potentially still a threat to some of England's endangered bryophytes, members of the BBS have long

adhered to a Botanical Code of Conduct (see www.britishbryologicalsociety.org.uk) and collect only sparingly, if at all. If confirmation was needed that British bryologists' behaviour has changed, an article by the American bryologist J.M. Glime (1983) is most revealing. On attending a BBS field trip in 1982 based at Okehampton in Devon, she observed that the British collect only a small bit of a species of uncertain identity, and this avoidance of collecting is based on new laws to protect mosses (WCA 1981 had recently been enacted) and on the realization that the botanists themselves had contributed to the demise of some species.

Dawson Turner's *The botanist's guide through England and Wales* published in two volumes in 1805 was one of the earliest publications to divulge where bryophytes grew (inasmuch as was known in those fledgling days of bryology). For example, in Devonshire *Splachnum turnerianum* [*Splachnum ampullaceum*] was said to be 'in a moor to the right hand side of the road about three miles from Sidmouth to Exeter'. Needless to say the 'moor' has long since been drained and the moss's specialized habitat lost. This was of course in an era when conservation as we now understand it did not exist in the minds of naturalists or the public. The pendulum ultimately swung in the opposite direction and, until recently, much secrecy and paranoia surrounded plant records. Fortunately, it seems a more enlightened outlook prevails amongst naturalists and conservationists today. Testament to this new-found transparency is the development of the National Biodiversity Network (NBN) database in which all natural history records (with a few exceptions) are in the public domain on the internet.

In defence of the earlier zealous collectors, who actually laid the foundations of our knowledge of bryophyte distribution and is indeed the justification for collecting mosses and liverworts today, a well-curated herbarium provides a permanent and indispensable resource for future workers. Specimens can be checked and reviewed in the light of new or improved knowledge, often revealing misidentified or overlooked species. The routine application of powerful molecular techniques provides insights into taxonomic problems and phylogenetic relationships that the earlier bryologist could scarcely have imagined. Furthermore, the herbarium is a treasure trove of information enabling analysis of distribution and status so crucial to the Red Listing process and ultimately to conservation.

Where are the bryologists of tomorrow coming from?

With the demise of bryology, and increasingly botany in general, on the UK university syllabus, the specialist societies and amateur bryologists probably have a greater role to play than ever before. Often the person will come to bryology from another natural history discipline, maybe flowering plants, or will have attended one of the many excellent and inspirational Field Studies Council (FCS) courses. That person also soon realizes that progress comes much faster and is more fun if they can combine with other beginners and experts. This is where groups such as the BBS can, and does, do so much to foster an understanding and appreciation of the diversity and an awareness of threats to the British and Irish bryophyte floras. Although the BBS is a relatively small society, it yields an authoritative voice on the conservation of British bryophytes. Plantlife International also champions the conservation of bryophytes and several excellent 'species dossiers' are available on their website, and the many Wildlife Trusts (based in each county) are likewise involved in a range of bryophyte conservation projects. The information technology age is an exciting time for young people, giving them a level of empowerment undreamt of by previous generations, but it has, to some extent, also alienated a generation from contact

with nature and hence concern for its plight. With the recent publication of the much needed *Field Guide* to British mosses and liverworts (Atherton, Bosanquet & Lawley, 2010), it is hoped that bryology will become much more accessible and encourage young people in particular to get involved and to value the bryological heritage of these islands.

What can be done?

There is much the novice or expert alike can do. Recording continues to be an important activity. The status and distribution of bryophytes is dynamic and surveys will always need repeating, and it is equally important to know what is happening to the 'common' species as well as the rare. Despite the long tradition of bryological recording in Britain, recording at the site level leaves much to be desired. Much of the recording of species is done at either the 10 km square level or, increasingly, at the tetrad (2×2 km) level. This is fine for distributional mapping at the country or county level, and indeed field work towards a new *Atlas of Bryophytes* is currently well advanced. Conservation usually operates at the site level yet it is surprising how difficult it is to be certain a species actually occurs within the boundary of an SSSI, for example, or indeed which species occurs on any particular site. Prepared with a site map showing its boundary, recording can include more detail such as frequency of occurrence, presence of capsules (termed 'fruiting'), habitat and substrate, and, in the case of rarer species, sketch maps pinpointing location.

On sites designated under the Habitats Directive, such as SACs, there is a requirement to report on certain listed species at least once every six years and this is also the standard accepted on all SSSIs in England. For organisms as challenging to identify as bryophytes, surveillance, particularly on this scale across all the designated sites, is a tall order. There is seldom adequate time allocated to a particular survey or status assessment but there are no 'short-cuts' and the quality of the information is only as good as that put in. Non-specialists may be able to report on habitat condition (under the Common Standards Monitoring programme) but this is no proxy for actually looking at the plant. There is thus a pressing need for competent bryologists to become involved in site monitoring. The presence/absence of a species is the minimum level of information required, but for threatened species more detailed surveillance is desirable entailing, for example, the use of electronic markers and digital imaging combined with Global Positioning System (GPS) technology – technologies that are increasingly available to fieldworkers.

It is sobering to contemplate how slowly some things change. Reporting on the 1986 BBS spring field meeting based at Dereham in Norfolk, R. Stevenson summed up the situation:

"Socially the trip seems to have been enjoyed by most people: bryologically it can only be described as average to dull. We failed to re-find more than a few of the recorded rarities of the region – and in most instances the culprit would appear to be habitat change, rather than incompetence. The need for conservation measures aimed specifically at bryophytes appears to be overwhelming even on those sites which are already Reserves. It looks as if we, as a Society, ought to be looking at the way in which we record the results of our endeavours. As the NCC² noted, after I had sent them our final results, site cards with a long list of names are of little use to a non-specialist especially if the card gives no indication of degrees of rarity, nor of the location of any rarities".

Although there has been substantial progress over the past 25 years in some areas, there remains much that the BBS can do in working with its conservation partners.

² the statutory nature conservation organisation of the day



Jeff Bates recording quadrats with the aim of identifying and characterizing bryophyte communities and relating them to environmental parameters. Photo: Joyce Bates

National Projects

Regular recording is supplemented by national projects undertaken collaboratively³. One project carried out by BBS members was an epiphyte survey of a tetrad transect across southern England and Wales (Bates *et al.*, 1997; 2004). This looked at the occurrence of bryophytes growing on trees and the data were logged onto customized recording cards. The subsequent analysis of the epiphytic-environmental relationship enabled a greater insight into the behaviour of epiphytes, a group of bryophytes well known for their sensitivity to pollution.

Another collaborative project looked at the bryophytes of arable land (Preston, Hill, Porley & Bosanquet, 2010). The survey ran for three years and data were collected on specially designed recording cards. A total of 808 arable fields were visited across Britain and Ireland, providing a sound baseline from which to assess future trends particularly with regard to the impact of Environmental Stewardship schemes. Little was known of the status of bryophytes in this hitherto largely neglected habitat or what impact the various farming practises were having on populations. Most of the bryophytes occurring on arable land are not considered threatened but a few rare or localized species do occur such as *Sphaerocarpos* spp., *Weissia squarrosa* and *Didymodon tomaculosus*. The arable bryophyte survey was successful on several fronts: it addressed a knowledge gap, and provided important data for ongoing analysis, a bench-line for future monitoring and information on common species. It also provided the impetus to produce an illustrated colour guide to arable bryophytes in Britain and Ireland (Porley, 2008). Agri-environment schemes seek to improve environmental

³ BBS members with, Plantlife International, the Natural History Museum (NHM), Centre for Ecology & Hydrology (CEH) and the statutory conservation agencies

quality at the wider landscape scale and populations of naturally common species might provide a good indicator of the success of such schemes. It is becoming increasingly apparent that even common species have undergone a substantial decline albeit without becoming threatened with eminent extinction (Gaston & Fuller, 2007).

The basic ecology of bryophytes is yet another key knowledge gap and the Bryophyte Ecology Group (known as BRECOG), the brainchild of Jeff Bates, has recently been inaugurated under the auspices of the BBS to look at fundamental aspects such as substrate preferences, reproductive characteristics and associated species. Some of the work will involve recording quadrats to characterize communities, together with environmental parameters such as slope, aspect, shade and so on. Ultimately the aim is to produce an 'ecological compendium' which brings together field data with relevant physiological data and other information in the literature. Virtually no information exists on the phenology of bryophytes – the timing of certain events such as fruiting or gametangia initiation (Bates, 2009). Bryophytes are potentially valuable indicators in climate change studies and if we better understood phenological responses to a changing climate then their usefulness as indicators would be greatly enhanced. A project such as this requires commitment but is definitely within the realm of amateur bryologists. Information on all the above activities and projects can be seen on the BBS website www.britishbryologicalsociety.org.uk.

The Red List

It is generally acknowledged that Britain is one of the most bryologically well-worked regions in the world (Crundwell, 1992; Cleavitt, 2005). A combination of the high quality distributional data, together with population data for some species, enables pragmatic assessments of the conservation status of bryophytes in Britain.

New bryophytes are added to the British list by an active group of recorders on an annual basis. England is no exception and within the last decade (2000–2010) at least ten new species have been added to the list. Some, such as *Seligeria campylopoda*, were added to the English (and British) list as a result of taxonomic studies, whilst others are regarded as introductions and hence of low concern (but see *Telaranea murphyae*, page 174). As a group, epiphytes, in particular, are undergoing rapid changes, with many species increasing their range within the British Isles, whilst some are being recorded for the first time (and will eventually require assessment under IUCN guidelines). Three recently discovered species are considered rare and threatened and have been placed on the revised British Red List: *Dialytrichia saxicola* (2005), *Timmia megapolitana* (2000) and the globally rare *Bruchia vogesiaca* (2006). Conversely, through taxonomic revision, species may be removed from the English list such as the formerly Red Listed and UK BAP moss *Brachythecium appleyardiae*, which has been shown to be a form of the widespread *Scleropodium cespitosum* (Blockeel *et al.*, 2005).

Nationally rare and scarce

For many years British bryophytes have been placed into two frequency categories compiled from records 1950 onwards:

- **Nationally Rare**, those that are present in 1–15 10 km grid squares; and
- **Nationally Scarce**, those that are present in 16–100 10 km grid squares.

quality at the wider landscape scale and populations of naturally common species might provide a good indicator of the success of such schemes. It is becoming increasingly apparent that even common species have undergone a substantial decline albeit without becoming threatened with eminent extinction (Gaston & Fuller, 2007).

The basic ecology of bryophytes is yet another key knowledge gap and the Bryophyte Ecology Group (known as BRECOG), the brainchild of Jeff Bates, has recently been inaugurated under the auspices of the BBS to look at fundamental aspects such as substrate preferences, reproductive characteristics and associated species. Some of the work will involve recording quadrats to characterize communities, together with environmental parameters such as slope, aspect, shade and so on. Ultimately the aim is to produce an 'ecological compendium' which brings together field data with relevant physiological data and other information in the literature. Virtually no information exists on the phenology of bryophytes – the timing of certain events such as fruiting or gametangia initiation (Bates, 2009). Bryophytes are potentially valuable indicators in climate change studies and if we better understood phenological responses to a changing climate then their usefulness as indicators would be greatly enhanced. A project such as this requires commitment but is definitely within the realm of amateur bryologists. Information on all the above activities and projects can be seen on the BBS website www.britishebryologicalsociety.org.uk.

The Red List

It is generally acknowledged that Britain is one of the most bryologically well-worked regions in the world (Crundwell, 1992; Cleavitt, 2005). A combination of the high quality distributional data, together with population data for some species, enables pragmatic assessments of the conservation status of bryophytes in Britain.

New bryophytes are added to the British list by an active group of recorders on an annual basis. England is no exception and within the last decade (2000–2010) at least ten new species have been added to the list. Some, such as *Seligeria campylopoda*, were added to the English (and British) list as a result of taxonomic studies, whilst others are regarded as introductions and hence of low concern (but see *Telaranea murphyae*, page 174). As a group, epiphytes, in particular, are undergoing rapid changes, with many species increasing their range within the British Isles, whilst some are being recorded for the first time (and will eventually require assessment under IUCN guidelines). Three recently discovered species are considered rare and threatened and have been placed on the revised British Red List: *Dialytrichia saxicola* (2005), *Timmia megapolitana* (2000) and the globally rare *Bruchia vogesiaca* (2006). Conversely, through taxonomic revision, species may be removed from the English list such as the formerly Red Listed and UK BAP moss *Brachythecium appleyardiae*, which has been shown to be a form of the widespread *Scleropodium cespitosum* (Blockeel *et al.*, 2005).

Nationally rare and scarce

For many years British bryophytes have been placed into two frequency categories compiled from records 1950 onwards:

- **Nationally Rare**, those that are present in 1–15 10 km grid squares; and
- **Nationally Scarce**, those that are present in 16–100 10 km grid squares.

The most recent assessment lists 82 liverworts and 172 mosses (Preston, 2006) as Nationally Scarce and 54 liverworts and 146 mosses (Preston, 2010) as Nationally Rare. Such lists were used in the past to aid in designating SSSIs, but whilst useful in certain contexts they are expressions of frequency of occurrence and do not necessarily reveal which species are actually under threat. As discussed in the section on 'Rarity in bryophytes' (page 13), most British bryophytes can, in some sense of the word, be considered rare but for a species to be considered threatened it must be at risk of impending extinction if nothing is done to secure its long-term survival. It is both the extent of decline in any particular population at the individual level or inferred from distribution changes and the size of a population (those with the smallest and fewest populations are most at risk) that are the crucial factors.

The IUCN criteria and categories

The IUCN has over the course of many years developed and refined the Red List categories and quantitative criteria designed to measure the extinction risk of threatened species (the first Red Lists focused on animals, and its later application to plants exposed some limitations such as defining what is meant by an individual). The IUCN Red List system is a probabilistic assessment of the likelihood that a species in a particular threat category will go extinct within some stated time frame – it cannot be used to provide a robust prediction about the fate of a particular species. Rather, the system envisages that a larger proportion of species listed in higher threat categories will go extinct over shorter periods.

The Red List process requires quantitative data to attain numerical thresholds, and because such information rarely exists for bryophytes it has to rely on inference from existing data (it is for this reason that Criterion C, detailed data on both population size and decline, and Criterion E, necessitating population viability data, of the IUCN guidelines are *not* employed in bryophyte Red Listing). Trends in abundance and range size are generally more important for listing of plant species than are single measures of absolute population size or areas of distribution. Specific guidelines for applying the scheme to bryophytes are given in Hallingbäck *et al.* (1998). Suffice it to say that the relevant data for Red Listing of bryophytes are population decline, number of sites, present distribution and total population size, and estimated loss of relevant habitats over the last ten years or three generations.

In 2001, two additional concepts were introduced with the new guidelines: **extent of occurrence** and **area of occupancy** (IUCN, 2001) and these are used in the revised British Red List. The first concept is defined as the area contained within the shortest continuous imaginary boundary that can be drawn to encompass all the known, inferred or projected sites of the present occurrence of a species, excluding cases of vagrancy. This is essentially similar to 'range' and may exclude discontinuities or disjunctions within the overall distribution, and may be estimated using conventional dot maps. The second term is defined as the area within its extent of occurrence, recognizing that a species will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats, and can also be determined by reference to dot maps.

The first Red List of bryophytes in Britain was published over a decade ago: *The British Red Data Book of mosses and liverworts* (Church *et al.*, 2001). Since then, knowledge of the status of British bryophytes has moved on and a revised Red List was recently published (Hodgetts, 2011). In particular, the revised list uses 1980 (instead of 1970) as the cut-off year to represent the threshold for the purposes of assessing decline, reflecting the increase in recording activity over the last 30 years. Collectively, the categories Critically Endangered

Summary of the thresholds of IUCN criteria as interpreted for the British bryophyte flora (based on Hodgetts, 2011)

Red List thresholds			
Criterion	Critically Endangered CR	Endangered EN	Vulnerable VU
A. Rapid decline	>80% over 10 years or 3 generations whichever is the longer	>50% over 10 years or 3 generations whichever is the longer	>20% over 10 years or 3 generations whichever is the longer
B. Small range, fragmented, declining or fluctuating*	1. Extent of occurrence <100 km ² a. Single location	1. Extent of occurrence <5,000 km ² a. 5 locations or fewer	1. Extent of occurrence <20,000 km ² a. 10 locations or fewer
	b. continuing decline observed, inferred or projected in any of the following: i. extent of occurrence ii. area of occupancy iii. area, extent and/or quality of habitat iv. number of locations/subpopulations v. number of mature individuals 2. Area of occupancy <10 km ² , using 1 hectad, and at least two of a–c: a. Single location	2. Area of occupancy <500 km ² , using 5 hectads, and at least two of a–c: a. 5 locations or fewer	2. Area of occupancy <2000 km ² , using 20 hectads, and at least two of a–c: a. 10 locations or fewer
	b. continuing decline observed, inferred or projected in any of the following: i. extent of occurrence ii. area of occupancy iii. area, extent and/or quality of habitat iv. number of locations/subpopulations v. number of mature individuals c. extreme fluctuations in any of the following* i. extent of occurrence ii. area of occupancy iii. number of locations/subpopulations iv. number of mature individuals		
D/D1. Very small population	<50 individuals estimated	<250 individuals estimated	<1,000 individuals estimated
D2. Very small range	–	–	5 or fewer locations

* only used in case of reservoir species since all bryophyte populations characteristically show fluctuations

(CR), Endangered (EN) and Vulnerable (VU) are described as ‘threatened’, and the term ‘Red List’ comprises threatened and extinct species only. IUCN have established a number of other categories including Near Threatened (NT) (close to qualifying for a threatened category in the future), Data Deficient (DD) (when inadequate information is available in order to make a threat assessment), Least Concern (LC) (in Britain a species is regarded as Least Concern if it occurs in ≥20 hectads post-1979 or in 16–19 hectads post-1979 and

shows no decline), and Not Evaluated (NE) (when a species has not been assessed against the criteria, such as aliens and synonymised species). These categories are outside the Red List and are not covered in this book (see Hodgetts, 2011 for species in these categories).

Selection of species for this book

The bryophytes covered in this book have been selected from the revised British Red List. These species do not constitute an English Red List *per se*. If the IUCN criteria were to be applied to English species – excluding data from Wales and Scotland – the resulting list would look somewhat different. Although the IUCN Red List criteria were developed to assess the extinction risk of species at the global level, experience and testing of the IUCN guidelines has shown that the system is applicable to a wide range of organisms and geographical scales (Mace, 2008; Gärdenfors, 2001). The criteria judge the risk of extinction within a given geographical area, whether small or large, and the thresholds are independent of the total size of the region. The extinction risk of a small and isolated population is as high in a small national boundary as it is in a large country or even a single global population.

One issue that still has to be resolved is the situation where a population is distributed over more than one country, since an immigration of propagules can affect the extinction risk of the subpopulation (the 'rescue effect'). The extinction risk of the subpopulation in the target country is therefore difficult to estimate; this problem is most acute in small land-locked countries compared to those surrounded by sea or other barriers preventing dispersal. Whilst Britain is an island and conveniently sea-locked, England, Wales and Scotland are clearly not. A Red List of England would first require the application of the criteria to all known English bryophytes and then a consideration of the impact of immigration of propagules on the national population. For bryophytes this is difficult to determine but the consequence would be to either upgrade the category if the regional population acts as a sink (e.g. VU to EN), or downgrade it if the immigration of propagules is thought to reduce the risk of extinction (e.g. EN to VU) (IUCN, 2003).

Overview of threatened English bryophytes

The English bryophyte flora currently totals 922 species, comprising 252 liverworts, 666 mosses and 4 hornworts. In all, 87 English species occur on the revised British Red List (Hodgetts, 2011), of which 24 are liverworts and 63 are mosses. About 9% of England's bryophyte flora is therefore at risk of extinction. Of the Red Listed species, 61 are also BAP priority species and 19 are fully protected under Section 13 of the Wildlife and Countryside Act 1981. Some 30 species (see page 203) have no post-1980 records and are considered to be lost from England (source Hill, Blackstock, Long & Rothero, 2008; Hodgetts, 2011 and NBN).

Threat Categories

Of the 87 English Red List bryophytes, 12 are CR, 30 EN and 45 VU (see Appendix 2). These include two mosses, *Bartramia stricta* and *Bryum cyclophyllum*, and one liverwort, *Scapania praetervisa*, that have not been seen in England for over 50 years (although recent records exist from elsewhere in the UK). They are not covered in the species profiles but are covered in brief accounts (see Appendix 1). *Grimmia arenaria* is also excluded, a species long considered synonymous with *G. donniana*, for example by the German bryologist

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K. G. Limpricht (1834–1902) and most recently by Maier (2010). At best it is considered a form of *G. donniana*.

The numbers of English mosses and liverworts in each threat category are shown in the following table. The Extinct category has been compiled using data from the revised Red List (Hodgetts, 2011), the Census Catalogue (Hill *et al.*, 2008) and the NBN; all species lack post-1979 records for England (see *page 200*).

Type of bryophyte	Extinct EX	Critically Endangered CR	Endangered EN	Vulnerable VU	Total CR, EN & VU
Moss	26	10	24	29	63
Liverwort	4	2	6	16	24
Total	30	12	30	45	87

Since the last assessment of the IUCN threat status of British bryophytes (Church *et al.*, 2001), three species formerly known from England have moved from CR to Regionally Extinct (*Bryum uliginosum*, *Dicranum elongatum* and *Tetradontium repandum*). A further 30 English species have been upgraded (mostly from Near Threatened) and seven have been downgraded. As of December 2011, overall 15 species on the original 2001 British Red List have been downgraded to Near Threatened on the revised list (Hodgetts, 2011), including 13 English species, resulting in removal from the Red List. They include the epiphytic moss *Habrodon perpusillus*, a plant that would likely remain on the Red List if it was assessed in the context of England alone. The changes are largely the result of improved data through fieldwork, taxonomic revisions (several ‘species’ have been synonymised) or additions to the British flora. Such changes make direct comparisons between the 2001 and 2011 Red Lists difficult in terms of species numbers across categories. In England, the overall trend in numbers of species in each of the three threat categories is downwards, despite *Dialytrichia saxicola*, *Timmia megapolitana* and *Bruchia vogesiaca* being added to the British list post-2001 and going straight onto the revised Red List. The only slight increase has been the number of English mosses categorized as VU (increased by four).

Where are the threatened English species?

The global and regional distribution of bryophytes is not random; instead, it follows recurring patterns allowing the recognition of phytogeographical (floristic) elements. Climate is a fundamental controlling factor determining large-scale distribution patterns whereas geology, soil, altitude, habitat, substrate and human impacts largely influence small-scale patterns (Hill & Lozano, 1994; Porley & Hodgetts, 2005). The spatial distribution of threatened bryophytes in England is also far from random. The all-species coincidence map (Fig 1) is a plot of *all* records of the 87 English bryophytes on the revised British Red List and indicates the number of species in each 20 km square. Two lowland clusters are immediately apparent in southern England where threatened species are particularly focused: a SW cluster centred on the Cornish mainland and the south Devon coast, and in the SE from the East Sussex coast north to the Weald. To some degree these areas rich in threatened species also reflect the distribution of the English bryophyte flora as a whole (Hill, Preston & Smith, 1991; 1994). The liverwort coincidence map (Fig. 2) shows that this group of threatened species is predominantly concentrated in the extreme SW of England (correlating with

high annual rainfall and number of wet days and presence of metal-rich soils), albeit not so markedly coastal as the mosses that are generally more tolerant of desiccation. No British liverwort grows where it is exposed to salt (halophyte) and the few liverworts that do show a coastal bias also occur inland in other parts of their range. On the other hand the moss coincidence map (Fig.3), whilst clearly confirming the strong south-west and south-east concentration, also reveals that threatened English mosses are more widespread, extending to Northumberland in the north with several occurrences in the Lake District. In contrast, *Nardia insecta* is the only threatened English liverwort to occur north of the Lake District.

The SW region is characterized by relatively dry, summer-parched coastal sites and higher January and July temperatures. The Lizard and Penwith peninsulas in Cornwall are notably rich

Fig.1: Coincidence map – all bryophytes

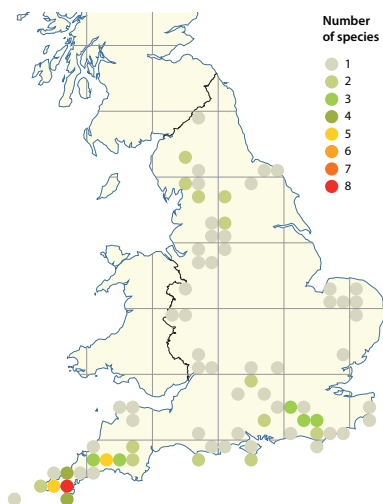
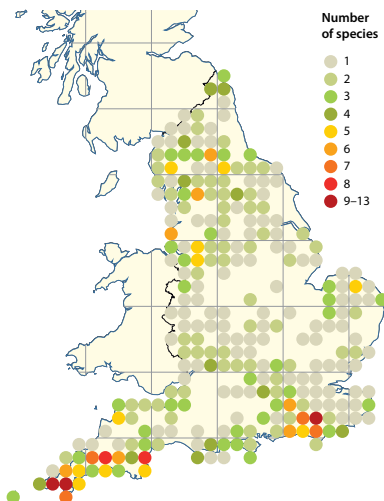


Fig.2: Coincidence map – liverworts

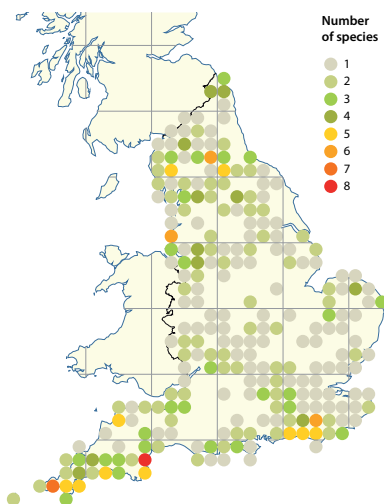


Fig.3: Coincidence map – mosses

in threatened species, including *Riccia bifurca*, *R. nigrella*, *Lejeunea mandonii*, *Cephaloziella dentata*, *C. integerrima*, *Cyclodictyon laetevirens*, *Ditrichum subulatum*, *Fissidens curvatus*, *F. serrulatus* and *Tortula solmsii*. Almost all these species belong to Mediterranean–Atlantic and Southern–temperate floristic elements. On the southern edge of Bodmin Moor, *Bruchia vogesiaca* and *Jamesoniella undulifolia* occur, and elsewhere old mine sites support *Cephaloziella massalongi*, *C. nicholsonii*, *Ditrichum cornubicum* and *Scopelophila cataractae*; these belong predominately to Oceanic and Suboceanic Southern–temperate elements.

The China Clay extraction industry around St Austell is home to the Oceanic Southern-temperate *Marsupella profunda*, and along the coast to Babbacombe Bay in south Devon occur the Mediterranean-Atlantic mosses *Cheilothela chloropus*, *Tortula wilsonii* and, formerly, *Weissia levieri*.

The SE cluster experiences warmer than average January and July temperatures and lower than average precipitation. Although a less cohesive group, many threatened bryophytes occur here. The Sussex coast supports the Mediterranean-Atlantic moss *Acaulon triquetrum* and a little further inland on the southern edge of the South Downs *Rhynchostegium rotundifolium*. The sandstone Weald creates its own humid microclimate and supports southern populations of the Oceanic Southern-temperate moss *Orthodontium gracile*. Formerly *Atrichum angustatum* occurred in the wooded areas of the Weald, and *Lophozia capitata* occurs north of the chalk on London Clay in Surrey.

It would be misleading to describe these areas as 'hot-spots'. A hot-spot is a biogeographic area with precisely defined parameters including a minimum number of species, endemics and occurrence of original habitat. Rather they can be regarded as IPAs (page 24), constituting a series of sites (SSSIs/SACs) that support a high concentration of threatened bryophytes and should inform landscape-scale policy decisions and enable targeting of finite conservation resources.

A noticeable feature revealed by the coincidence maps is that extensive tracts of England, from approximately the Thames north to Cheshire, Lancashire and Cumbria, support few, if any, threatened bryophytes. There could be many reasons for this situation, not least the scarcity or absence of suitable habitat as a result of human impact and other factors such as pollution. The Lake District, and to a lesser extent the Pennines, formerly supported many threatened species; indeed the vast majority of the species that have apparently vanished from England occurred in this area, which suggests that targeted fieldwork in Cumbria, North Yorkshire and Durham may be particularly rewarding.

Habitat

The habitat preferences of the 87 English threatened bryophytes (including *Bartramia stricta*, *Bryum cyclophyllum* and *Scapania praetervisa*, thought to be extinct in England – see Appendix 1) were evaluated using BRYOATT (Hill *et al.*, 2007) and is presented below. The treatment of habitats is based on the classification system of EUNIS (European Nature Information System). This is a hierarchical arrangement standardized across Europe, of habitats or biotopes (areas with particular environmental conditions that are sufficiently uniform to support a characteristic assemblage of organisms). Level 1 of the hierarchy represents broad biotopes such as Coastal habitats, Mires, bogs and fens and Woodland, forest and other wooded land. BRYOATT uses level 2 of the hierarchy (for example Coastal dunes and sandy shores within the Coastal biotope) and for the present analysis only the normal habitat of the species was taken into account (rare or occasional habitats for a species were disregarded). It should be noted that whilst many bryophytes are restricted to one or two habitat types, the majority occupy a series of habitat types and therefore a species may be 'scored' more than once when analysing habitat occurrence (see Appendix 2). It should be noted that BRYOATT is based on attribute data from Britain and Ireland.

- **Inland cliffs, rock pavements and outcrops** (EUNIS level 2 H3). The largest number of species (28%) occurs within this habitat. It includes sea-cliffs not directly exposed to salt spray, cliffs inland, limestone pavement and disused quarries. Species include *Didymodon glaucus*, *Grimmia elongata*, *Mielichofferia elongata* and *Philonotis marchica*.

- **Miscellaneous inland habitats with sparse or no vegetation** (EUNIS level 2 H5), has the second largest group of species (19%). It includes block slopes, clay, silt, sand, gravel and rocky soils, for example on open or bryophyte dominated soil banks by tracks or on ditch, stream and river banks well above water level. Species include *Bruchia vogesiaca*, *Ditrichum subulatum*, *Lophozia capitata* and *Riccia nigrella*.
- **Extractive industry sites** (EUNIS level 2 J3). The third largest group of species (18%) occur within a sub-division of the Level 1 hierarchy: 'Constructed, industrial and other artificial habitats'. It includes active mines and opencast sites such as sand and gravel workings and recently abandoned extraction sites. Examples include *Cephaloziella nicholsonii*, *Marsupella profunda*, *Scopelophila cataractae* and *Tortula cernua*.
- **Rock cliffs, ledges and shores** (EUNIS level 2 B3). The fourth largest group of species (17%) belongs to Level 1 'Coastal habitats'. It includes rocky shores, rocky cliffs with salt-tolerant species and vegetated soft cliffs such as landslip. Species include *Cyclodictyon laetevirens*, *Didymodon cordatus*, *Southbya nigrella* and *Weissia multicapsularis*.
- **Littoral zone of inland surface waters** (EUNIS level 2 C3). This group includes lake and river shingles, reservoir margins and spray zones of waterfalls, and those parts of banks or shores that are sufficiently frequently inundated to prevent the formation of closed terrestrial vegetation: 16% of the species occur in this group, including *Andreaea frigida*, *Dumortiera hirsuta*, *Micromitrium tenerum* and *Thamnobryum angustifolium*.
- **Low density buildings** (EUNIS level 2 J2). Another sub-division of Constructed, industrial and other artificial habitats, this group includes scattered residential buildings, agricultural buildings, fences, field walls and rural churchyards: 15% of the species occur in this group, including *Rhynchostegium rotundifolium*, *Southbya tophacea*, *Tortula cuneifolia* and *Zygodon gracilis*.
- **Broadleaved deciduous woodland** (EUNIS level 2 G1). This group includes semi-natural broadleaved woodland, orchards and species growing on rocks in woodland (but excludes woodland rides): 12% of the species occur in this group, including *Anomodon attenuatus*, *Lejeunea mandonii*, *Orthodontium gracile* and *Zygodon forsteri*.

The largest proportion of threatened English bryophytes occurs in the EUNIS level 1 biotope 'Inland un-vegetated or sparsely vegetated habitats' (EUNIS code H) in subdivision H3 'inland cliffs, rock pavements and outcrops'. This includes non-coastal habitats that are open, dry or only seasonally wet and relatively free of competition from other vegetation (EUNIS definition is less than 30% vegetation cover). A large proportion of the British bryophyte flora (61%) also occurs in H3, which is not unexpected given that most bryophytes are poor competitors. It includes dry calcareous and non-calcareous cliffs, rock surfaces exposed by glacial erosion (such as limestone pavement) and weathered rock outcrops (scree are excluded). Although colonists are particularly well represented, perennial stayers are more characteristic of this habitat than any other. Miscellaneous inland habitats (EUNIS H5) are characterized by species of disturbed or trampled soils such as track, ditch and stream banks where other vegetation is absent or very sparse, and includes the global rarity *Bruchia vogesiaca*. The habitat supports a large proportion of threatened English bryophytes, many of which are annual shuttle species and colonists reflecting their adaptation to disturbance.

Amongst the English species on the revised British Red List is a suite of rare species of anthropomorphic habitats or in EUNIS terminology 'Constructed, industrial and other artificial habitats' (EUNIS J). It includes abandoned and active mines and quarries and other extractive industries (EUNIS J3). Several rare bryophytes have adapted to soils (*Ditrichum*

cornubicum) and surface water (*Cephaloziella massalongi*) contaminated with heavy metals and highly alkaline waste (*Tortula cernua*). In comparison with the total British bryophyte flora overall, rare species are disproportionately represented in these extreme environments. Closely allied is EUNIS J2, 'low density buildings', and includes walls and old mine buildings. The species are predominately colonists.

Coastal habitats (EUNIS code B) are also of major importance for threatened English bryophytes and include sand dunes, moist and humid dune slacks, soft vegetated sea-cliffs and hard rocky sea-cliffs. Several mosses tolerate a degree of salt-influence, such as *Tortula wilsonii* on sea cliffs exposed to storm-driven salt-spray and *Bryum marratii* on the upper edges of saltmarsh. Colonists continue to be well represented in coastal habitats but short-lived and annual shuttle species are also strongly represented.

The littoral zone of inland surface waters (EUNIS C3) predictably supports a large range of British bryophytes and includes rivers, springs and water bodies that may dry out for part of the year. Threatened English species include those of fast flowing rivers and streams such as *Thamnobryum cataractarum* and a suite of species characteristic of the draw down zone of lakes and reservoirs such as *Ephemerum cohaerens*. There is a wide range of life history strategies in this group, but *Micromitrium tenerum* and *Physcomitrium eurystomum* are the only two English threatened species classed as strict ephemerals.

A large proportion of British bryophytes occur in woodland and so it is not surprising that several rare English species are to be found here. Few are strict epiphytes (*Zygodon forsteri* is one); rather they grow on rocks or in rides (such as *Anomodon longifolius* and *Atrichum angustatum*) within the woodland. They tend to be more or less equally divided between colonists and perennial stayers.

An additional 18 EUNIS level 2 habitats support English species on the revised British Red List but none comprises more than 7% (most less than 3%) of the total number of species. They are no less important in conservation priorities; for example within the **Mires, bogs and fens** (EUNIS level 1 code D) both valley mires and base-rich fens (EUNIS D2 and D4 respectively) supports rapidly declining species such as *Tomentypnum nitens* and blanket bog is home to a species not seen in England for many years, *Aplocladon wormskioldii*.

Substrates

Whereas substrate is relatively unimportant for British vascular plants, most of which are rooted in soil, it is much more relevant to bryophytes (Hill *et al.*, 2007). As noted in the 'Rarity in bryophytes' section (page 13), the niche breadth of a bryophyte is defined by both its habitat and substrate which clearly has implications for its rarity. Each of the 87 English species on the revised British Red List was allocated a substrate class following BRYOATT (see Appendix 2).

- **Soil:** In common with the British bryophyte flora as a whole, more than half (56%) of the threatened English species occur on soil (mineral, sandy, gravelly, humus-rich and peaty).
- **Hard rock:** A little over 50% of the British bryophyte flora occurs on hard rock, and therefore not unexpectedly a high proportion (29%) of threatened English species also grows on hard rock, including *Grimmia elongata* and *Zygodon gracilis*.
- **Soil on rock:** Defined as a thin layer of soil over rock, 21% of threatened English species are associated with this substrate including *Liochlaena lanceolata* and *Tortula cuneifolia*. Many species in this class also grow directly on rock or on soil.

- **Soft rock:** Includes chalk, soft sandstone and schists. It provides the substrate for 17% of the threatened English species including *Didymodon glaucus* and *Mielichhoferia elongata*.

Threatened English species are encountered in a further eight substrate classes but none comprises more than 8% of the total. Very few (7%) threatened English species are epiphytes on living wood compared to the number of epiphytes in the British flora as a whole (about 25%). Only two threatened liverworts grow amongst or through other bryophytes (*Jamesoniella undulifolia* and *Lophozia herzogiana*) and only one liverwort grows epiphytically on other bryophytes (*Lejeunea mandonii*). Perhaps the substrate most at risk with relevance to English threatened bryophytes is decaying animal matter, including bones, soft parts of carcasses and dung. Changes in animal husbandry, strict EU regulations on the removal of fallen animals and the use of broad-spectrum antiparasitic medicines (which may alter the decomposition properties of dung), together with habitat changes, may, in part, be causing a decline (quantity and quality) in this specialized substrate. Two bryophytes depend upon decaying animal matter, at least for initial establishment: *Aplodon wormskioldii* which may already be extinct in England and *Splachnum vasculosum* which is declining.

Floristic elements

Hill & Preston (1998) defined floristic elements to enable the establishment of categories with similar climatic requirements and is a system based on present distributions of bryophytes in Europe and western Eurasia. Essentially it divides the flora up firstly into latitudinal categories and secondly into longitudinal ones. Nine major bryofloristic elements are recognized in the British and Irish flora and their relative proportions (endemics have been omitted from the data) are compared to their representation within the subset of the 87 English bryophytes on the revised British Red List. Some elements are less sharply distinct from other elements, such as the Arctic–montane and Boreo–Arctic Montane. Each of the major biome categories is further subdivided according to the eastern limits of their distribution and two categories are especially relevant to bryophytes, Hyperoceanic Temperate and Hyperoceanic Southern–temperate (although together they only constitute about 5% of the British and Irish flora). Hyperoceanic bryophytes have a markedly western distribution in Britain and are rare on the European mainland. Only the Hyperoceanic Southern–temperate element is represented amongst the threatened English species and comprises only three species, all Endangered (*Cyclodictyon laetevirens*, *Lejeunea mandonii* and *Telaranea europaea*).

When considering the geographical relationships of the 87 English bryophytes listed on the revised British Red List, it is apparent that a relatively high proportion, greater than in the British and Irish flora as a whole, belong to the Mediterranean–Atlantic element: a group that includes species that are fairly strictly confined to the Mediterranean zone and Atlantic fringe of Europe. In Britain, the element is concentrated in SW and southern England and the coast of northern Wales (Hill & Preston, 1998). Given that they are absent from, or have at most only a few occurrences in, Central Europe underlines their high conservation priority in the European context. Within this element there is one Critically Endangered British species, *Bartramia stricta* (see pages 204–5 and Appendix 1), although this has been extinct in England for nearly 150 years, six Endangered species (more in this element than in any other) and 11 Vulnerable (see Appendix 2).

Intuitively, one might have expected the more southerly phytogeographical groups and their habitats to be less threatened by climate change; indeed most British bryophytes have

	British & Irish	English Red Listed
1. The Arctic–montane elements	7%	4%
2. The Boreo–Arctic Montane elements	13%	10%
3. The Wide–boreal elements	2%	–
4. The Boreal–montane elements	20%	18%
5. The Boreo–temperate elements	17%	6%
6. The Wide–temperate elements	2%	1%
7. The Temperate elements	19%	23%
8. The Southern–temperate elements	10%	16%
9. The Mediterranean elements	10%	20%

northerly affinities and the Arctic–montane species in particular have restricted ranges and may be particularly vulnerable to anticipated changes in climate (Bates & Preston, 2011). It is conceivable that as climate change intensifies, conditions for those bryophytes with southerly affinities will become more favourable. This is already evident in vascular plants (Preston *et al.*, 2002), as exemplified by Mossy Stonecrop, Spotted Medick and Wild Leek (Mediterranean species tend to grow in open or disturbed habitats and are less faithful to specific sites, confounding explanations of change). However, many causal factors contribute to the decline of a species, and habitat loss, fragmentation and a general reduction in habitat quality (*e.g.* through eutrophication) are major problems for species adapting to climate change.

The floristic element with the most Critically Endangered species in England is the European Temperate element, albeit with only three species (*Atrichum angustatum*, *Didymodon glaucus* and *Rhynchostegium rotundifolium*). This is also the third largest element in the British and Irish flora and the high proportion (but still well below that of the Mediterranean–Atlantic element) of threatened English species belonging to this group is a reflection of this. The Boreal–Montane element also has a high representation of threatened English species and indeed is the largest major biome category in the British Isles. The group is concentrated in the western mountains of Britain, particularly Scotland. The European Boreal–montane element in particular comprises many species that are rare or very rare in the British Isles and in England the element has one Critically Endangered (*Liochlaena lanceolata*) and seven Vulnerable species, three of which (*Andreaea frigida*, *Cynodontium polycarpon* and *Nardia insecta*) occur at moderately high altitudes in the hills of the Lake District and N Northumberland.

Sexuality and asexual propagules

Of the 24 English liverworts listed on the revised Red List of British bryophytes, 13 are monoicous and nine are dioicous (sexuality is unknown in *Plagiochila norvegica* and *Dumortiera hirsuta* can be monoicous or dioicous) and of the 63 threatened English mosses 32 are monoicous and 30 are dioicous (sexuality is unknown in *Thamnobryum cataractarum*) (see Appendix 2). Of the 84 extant English species (omitting the three vanished bryophytes mentioned above), 16, comprising ten liverworts and six mosses, have some kind of asexual propagules. Protonemal gemmae are excluded from the analysis because of a lack of data but many British bryophytes almost certainly have them, including the Red Listed mosses *Orthodontium gracile*, *Orthotrichum pumilum* and *Zygodon forsteri*. The presence

of asexual propagules is more or less equally distributed between dioicous and monoicous liverworts indicating independence of sexuality, but there are more dioicous mosses with asexual propagules than monoicous species. In terms of sporophyte production amongst the threatened English species, 14 mosses lack sporophytes or are very rare, whilst only two liverworts (both dioicous) lack sporophytes. All the liverworts and mosses that have asexual propagules also tend to show the colonist life-history strategy.

Designated sites

A species' ability to adapt to climate change and other threats is closely linked not only to its reproductive biology and dispersal ability but also to the quality of the habitat and how fragmented that habitat is. In principle there is more scope for managing a piece of land sympathetically for bryophytes if it has been designated as an SSSI. The European designated sites collectively known as 'Natura 2000' such as SACs and SPAs are also notified as SSSIs. About 82% of threatened English bryophytes occur on at least one SSSI. In many instances, all known populations of a species are within SSSIs, such as *Acaulon triquetrum*, whilst populations of others may be only partially represented on SSSIs.

Occurrence within an SSSI may safeguard a species against certain damaging activities but the network can offer little protection from eutrophication, pollution or climate change. Crucial here is the connectivity of the designated sites system so that a species can either avoid the threat or move to more suitable 'climate space'. The high level of fragmentation of semi-natural habitat is a significant constraint to the movement of many groups of plants and animals in the English countryside, including bryophytes.

In England, 19% of threatened bryophytes on the revised Red List of British bryophytes do *not* occur on an SSSI as far as it is known. A few have older records from SSSIs but no known recent occurrences have been reported, including *Bryum gemmiparum*, *Lioclaena lanceolata*, *Tomentypnum nitens* and *Tortula vahliana*. In some cases, a lack of data means it is uncertain whether a species is represented within the SSSI network although the following bryophytes are currently not known to occur on any English SSSI (those that are fairly certain to have vanished are not included):

<i>Bryum gemmiparum</i>	<i>Orthotrichum pumilum</i>
<i>Ceratodon conicus</i>	<i>Philonotis marchica</i>
<i>Cyclodictyon laetevirens</i>	<i>Plagiochila norvegica</i>
<i>Cynodontium polycarpon</i>	<i>Seligeria diversifolia</i>
<i>Dialytrichia saxicola</i>	<i>Splachnum vasculosum</i>
<i>Lioclaena lanceolata</i>	<i>Telaranea europaea</i>
<i>Micromitrium tenerum</i>	<i>Tomentypnum nitens</i>
<i>Nardia insecta</i>	<i>Tortula vahliana</i>
<i>Orthotrichum pallens</i>	

Some bryophytes at high risk of extinction do occur on SSSIs, but also have significant populations outside the SSSI series. For some species, SSSI designation may not be the most effective or appropriate mechanism; a good example is *Marsupella profunda* (page 127). Conservation at the landscape level and the creation of favourable conditions at a wider scale are key to safeguarding this species.

Threats and drivers of change

The individual species profiles disclose many of the threats bryophytes are exposed to in England. The impact of climate change, discussed in the context of floristic elements, habitat loss and modification of semi-natural habitat have been noted throughout this book. Although much habitat fragmentation took place in the past, the process is ongoing and isolated fragments continue to lose species for many reasons, including nutrient input, invasion of alien species and undergrazing or overgrazing. Bryophytes benefited greatly, and to a much lesser extent still do, from the grazing activity of rabbits in creating and maintaining small pockets of open ground. The collapse of the rabbit population following myxomatosis in the 1950s probably led to the demise of countless populations of small mosses and liverworts.

The impact of human activity over a long period of time has also led to an excessive input of nutrients (predominately nitrates and phosphates) into soil and water as a result of fertilizer run-off, livestock farming and pollution from vehicles, a process known as eutrophication. Bryophytes are poor competitors and most are adapted to infertile sites. Nitrogen values (a general indication of the fertility of sites) were allocated to the 87 threatened English species (see *Appendix 2*) and the Extinct species following BRYOATT (Hill *et al.*, 2007). Most of the species listed as Regionally Extinct in the revised Red List of British bryophytes vanished a long time ago, probably as a result of habitat loss. The majority of these Regionally Extinct species correspond to nitrogen value 3 (indicators of moderately infertile sites) and value 4 (intermediate between moderately infertile and moderately fertile sites).

Many of the species not seen in England for more than 50 years (Hill, Blackstock, Long & Rothero, 2008) (see *page 203*) correspond to nitrogen values 1 and 2, indicating an adaptation to extremely infertile and infertile sites respectively. Some were known to persist into the 1950s, such as *Conostomum tetragonum*, *Didymodon icmadophilus* and *Philonotis tomentella*. A plausible hypothesis is that eutrophication may be a more contemporary driver of losses of bryophytes (although equally some of the species not seen in England since the beginning of 1960 may still be present but simply overlooked). For vascular plants there is increasing evidence that eutrophication has been a driver of change across a range of habitats, with the result that there has been a loss of species of infertile habitats (Braithwaite, Ellis & Preston, 2006; Preston *et al.*, 2002). Coupled with the impact of eutrophication is evidence that taller vascular plants have an advantage over shorter plants, with the latter being out-competed (Preston *et al.*, 2002). Small bryophytes, growing at the feet of the flowering plants, are especially vulnerable.



The species profiles

This section presents species profiles accompanied by photographs of 84 of the 87 threatened bryophytes on the revised British Red List (Hodgetts, 2011) that occur in England. If a photograph was not taken in England this is indicated. Three bryophytes on the Red List (*Bartramia stricta*, *Bryum cyclophyllum* and *Scapania praetervisa*) have not been recorded in England for more than 50 years and are therefore excluded from the profiles (see *page 206*).

Both common and scientific names are given (see also *Appendix 2*). English names for bryophytes follow Edwards (2012) and the nomenclature for scientific names follows Hill, Blackstock, Long & Rothero (2008), as too does the taxonomic Order to which the species belong (Order names end with *ales*, for example Dicranales).

Each profile indicates the status and attributes of the species as follows:



= Moss



= Liverwort

IUCN threat category:



= Critically Endangered



= Endangered



= Vulnerable

An indication is given as to whether the species' status has remained unchanged since the last Red List was published (Church, Hodgetts, Preston & Stewart, 2001), or has been upgraded or downgraded according to the revised British Red List.

One of more codes are included at the beginning of the species profile to summarize the legislative protection it is afforded (if any), to indicate if it is a BAP priority species, and to specify whether it is Nationally Rare or Nationally Scarce. The following codes are used:

H&S = listed on Annex II of the EU Habitats and Species Directive.

WCA = listed on Schedule 8 and fully protected under the Wildlife & Countryside Act 1981.

BAP = listed as a priority species in the UK Biodiversity Action Plan.

NR = Nationally Rare (present in 1–15 10 km grid squares).

NS = Nationally Scarce (present in 16–100 10 km grid squares).

The profiles include a brief description of the species, comments on habitat and substrate preferences and distributional information. An indication of size is given in the text, although it should be stressed that this is very variable and for this reason scale bars are not shown on the images. The assignment to floristic elements follows Hill & Preston (1998) updated from BRYOATT Attributes of British and Irish mosses, liverworts and hornworts (Hill, Preston, Bosanquet & Roy, 2007). Occurrence of a species is normally referred to in the context of an administrative county boundary such as Suffolk, but the traditional botanical recording unit is also occasionally used, known as the Watsonian vice-county (Dandy, 1969). Vice-county boundaries are fixed and are more or less of equal land areas, Suffolk for example being divided into East Suffolk (vice-county 25) and West Suffolk (vice-county 26).

The profiles briefly review the history of the species' history in England and the contributions of past and present day bryologists and those involved in their conservation. The literature has been widely consulted for historical information although the National Biodiversity Network (NBN), in particular, has been especially valuable in providing dates of first English records and recorders. However, the NBN is not the definitive authority and therefore responsibility for any errors rests with the author. Conservation action (if any), including *ex situ* conservation, is considered alongside potential and actual threats and possible reasons for any decline. The representation of a species on designated sites, including Sites of Special Scientific Interest (SSSIs) and Special Areas of Conservation (SACs), where known, is also given.

Each profile is accompanied by a map of Great Britain that shows the distribution of the species in 20 × 20 kilometre squares. Scotland and Wales have been included on the map in order to provide an overview of the species' distribution beyond the English borders. In presenting the distribution data, a distinction has been made between records made during the 21st century and those before. The following colour-coding is used:

- Record made before 2000
- Record made in or after 2000

It is important to recognize that a pale green dot does not necessarily imply that a species is absent post-2000. *Fissidens serrulatus* is a case in point; although there are no post-2000 records in the national database, it is in all likelihood still present along the River Dart in Devon. The maps show records submitted and processed up to September 2011; subsequent discoveries made up to December 2012 are mentioned in the text. Ten years or so is not a sufficient time interval to categorically pronounce the loss of a population, and some species are inevitably better recorded than others. The maps represent the known distribution of England's most threatened bryophytes at the close of the first decade of the 21st century.

Abbreviations used in the species profiles

a.s.l.	Above sea level	NE	North-east
BBS	British Bryological Society	NE	Natural England
BI	British Isles	NERC Act	Natural Environment and Rural Communities Act 2006
C	Central	NHM	Natural History Museum
CEH	Centre for Ecology and Hydrology	NNR	National Nature Reserve
Defra	Department of Environment, Food and Rural Affairs	NP	National Park
E	East	NT	National Trust
EA	Environment Agency	NW	North-west
EC	European Commission	RBGE	Royal Botanic Gardens Edinburgh
EN	English Nature	RBGK	Royal Botanic Gardens Kew
EU	European Union	RDB	Red Data Book
FC	Forestry Commission	S	South
HAP	Habitat Action Plan	SAC	Special Area of Conservation
IoS	Isles of Scilly	SE	South-east
IoW	Isle of Wight	SPA	Special Protection Area
JNCC	Joint Nature Conservation Committee	SSSI	Site of Special Scientific Interest
LPA	Local Planning Authority	SW	South-west
MoD	Ministry of Defence	W	West
N	North	WCA	Wildlife & Countryside Act 1981
NCC	Nature Conservancy Council	WT	Wildlife Trust

*Acaulon mediterraneum***Spiny-spored Pygmy-moss**

VU

NR

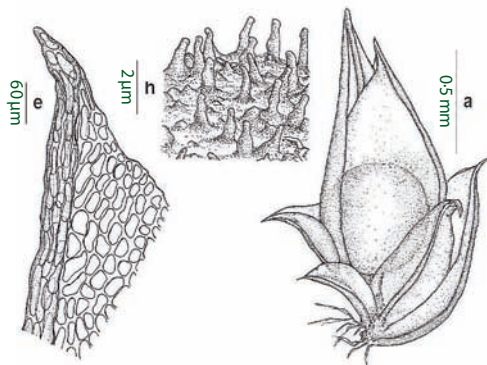
Upgraded

This is an exceedingly minute moss, only 1.5 mm or less tall forming scattered turfs. The genus *Acaulon*, meaning 'without a stem', comprises some of the smallest mosses in Britain. The leaves are broadly oval with a nerve that ends in, or slightly extends beyond, the obscurely toothed apex and is bent slightly backwards. It is monoicous and sporophytes are common but are hidden by the concave, overlapping leaves that give the plant a bud-like appearance. Microscopic examination of spores is necessary to separate it from its congener *A. muticum*; spores of *A. mediterraneum* have long spines. Asexual propagules are unknown and it behaves as an annual shuttle, producing relatively large spores that germinate in seasonally predictable micro-sites.

It is an ephemeral of disturbed open soil, predominately, but not exclusively, on the coast. It occurs on cliff tops, on thin soils amongst rocky outcrops, along paths and tracks, on open patches in pasture and south-facing hillsides, on Cornish 'hedges' and, more rarely, on cultivated ground. It is intolerant of shading or competition and disappears during the summer months. Its few associates include other small short-lived bryophytes including *Ephemerum serratum*.

It is a member of the Mediterranean–Atlantic element, known from France, Portugal, Spain, Sardinia, Italy, Crete, Greece, Croatia and Montenegro. It extends north to England and southern Sweden. Elsewhere it occurs in Turkey, the Canary Islands and Australia. The earliest English record traced so far is attributable to R. V. Telham (1826–1908) who collected it from Bodmin, E Cornwall, in 1893.

The distribution in England is not fully known as it has only recently been accepted as a 'good' species, rather than a variety of *A. muticum* (the recording of varieties tends to be inconsistent).



Acaulon mediterraneum, one of England's tiniest mosses. The illustration shows the leaves concealing the round capsule (a), the bent back leaf tip (e) and the spiny spore coat (h) crucial for correct identification. (Reproduced with permission of J. Guerra, from *Flora Briofítica Ibérica* Vol. III)



Acaulon mediterraneum

A herbarium study by D.T.Holyoak clarified its occurrence in Britain (Holyoak, 2003): it is known from five vice-counties in about 10 localities and its distribution is centred on Cornwall. There are old records from S Devon and S Somerset where it was last seen in 1956 and 1935 respectively and a record from the Isle of Man (in Braithwaite, 1887) dated 1886 has been re-determined as *A. muticum* (L. Hedenäs, pers comm.). Post-2000 it has been collected near Greeb Point, E Cornwall, by DTH and F.J. Rumsey in 2002 on top of a Cornish ‘hedge’, and most recently by R. V. Lansdown and FJR in 2004 on rabbit-disturbed sandy ground near Farncombe in Surrey, about 50 km inland from the coast.

Little is known of potential threats. It is currently recorded on three SSSIs (Aire Point to Carrick Du and Talland Barton Farm in E Cornwall, and Kennack to Coverack on the Lizard in W Cornwall, the latter within the Lizard SAC). There is no specific conservation action aimed at this species and it is not on the UK BAP. It may benefit from climate change given that it is a species with Mediterranean affinities although its dispersal potential is probably limited. It was not evaluated for the previous Red Listing process (Church *et al.*, 2001), but in the revised British Red List it is classified as Vulnerable on the basis of a very small range with five or fewer locations post-1980.

M

POTTIALES

Acaulon triquetrum

Triangular Pygmy-moss

EN

BAP; WCA; NR

No change

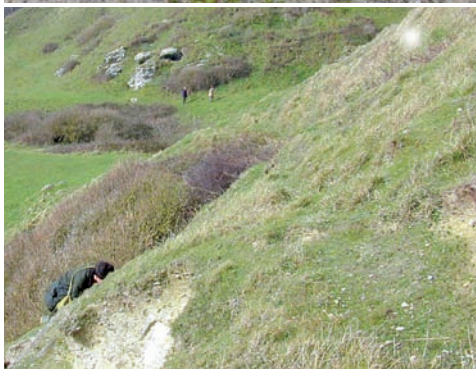
This species is one of England’s smallest mosses, forming reddish or golden-brown scattered turfs of shoots to 1.5 mm or less. The leaves are strongly keeled with a bent back leaf tip giving it a distinctive triangular form (hence *triquetrum*). It is monoicous and sporophytes are common with the capsule held to one side on a short curved seta. Asexual propagules are absent. It shows an annual shuttle life-history strategy, with high reproductive effort invested in producing relatively few large spores.

It grows on bare, usually calcareous, soils close to the sea with a preference for south-facing slopes and on grassy cliff-tops where the turf is kept open by soil slippage or trampling by grazing animals. It also colonizes hoof imprints and other scuffed patches in turf, and grows on thin drought-prone soils amongst rock outcrops, alongside tracks and on turf-cutting scars. It is often associated with a range of other small acrocarpous mosses. A winter annual, it disappears completely in summer, and germinates from a spore bank when the autumn rains arrive.

A member of the Submediterranean–Subatlantic element, it is widespread in the southern European countries, in W and C Europe extending east to the Ukraine. Elsewhere it is known from Turkey, N Africa, the Canary Islands, Iraq, N America and Australia. In the BI it is restricted to southern England where it reaches the northern limit of its distribution. The earliest English record, in 1844, was made by the Sussex botanist W. Borrer (1781–1862) on cliff tops around Brighton.

In Sussex today the plant is not doing so well. It has disappeared from most of its historical localities and today is currently known from just one small area of rank cliff-top grassland near Newhaven, initially found at this spot by E.C. Wallace in 1951, but is at risk from eutrophication by dogs (Hodgetts, 2004a). On the Isle of Wight it was first discovered in

RIGHT: *Acaulon triquetrum* occupying its usual niche on bare calcareous soil. Photo: Štěpán Koval (Czech Republic).
 BELOW LEFT: The sharply keeled leaves of *Acaulon triquetrum* give a distinctive jizz to the bud-like shoots. Photo: Štěpán Koval (Czech Republic).
 BELOW RIGHT: *Acaulon triquetrum* at St. Catherine's Down, Isle of Wight. Photo: Ron Porley.



1923 on Afton Down, by Army and Navy stores worker J. Groves F.L.S. (1858–1933) but there is no longer any sign of it here. Fortunately another population was found on the island in 1964 during a BBS meeting to St. Catherine's Down; it is still present here in cattle-grazed turf kept open by disturbance, soil slippage and rabbit activity.

The stronghold of *A. triquetrum*, however, is in Dorset. First found by E. M. Holmes (1843–1930) on the Isle of Portland and subsequently collected in 1906 by W. Mitten (1819–1906), there was to be no further records from Portland for over 90 years until B. Edwards, carrying out a survey of Dorset under the UK BAP, discovered c. 300 plants at Penn's Weare in 1999. In 1951, E. C. Wallace (1909–1986) found it at Emmetts Hill, on the Purbeck Ridge, the first record outside Portland. BE re-found it here in 1999 and estimated that c. 3,000 plants occur on a predominately west-facing, slumping undercliff; possibly there is more waiting to be found at this site but access to the unstable undercliff is dangerous especially following heavy rain. Also, on the cliff-top at Dungy Head near Lulworth Cove at least 2,000 plants were seen, and at Mupe Bay c. 500 plants were discovered. In total it is known from four sites in Dorset.

The moss is fully protected under the WCA 1981 and all known populations occur on SSSIs (Isle of Portland and South Dorset Coast SSSI) and in the Portland to Studland Cliffs SAC. There is no special management for the plant; its survival depends on habitat management (grazing) and natural events such as soil slippage and slumping of undercliff. Populations should be monitored at least once every six years under the SSSI surveillance framework to detect any change, and the population at Dungy Head in Dorset is currently

the subject of a detailed monitoring programme. It is uncertain how climate change will affect *A. triquetrum*; summers may be characterized by increasing aridity and some grasslands may become unsuitable for grazing allowing coarse grassland types, such as Tor-grass, to expand. On the other hand, greater dieback of grasses due to drought may lead to more bare ground and greater opportunities for annual and desiccation-tolerant bryophytes. Coastal erosion due to increased frequency and intensity of winter storms and rising sea levels (Hughes, 2003) may offset any such gains.

At least in the short to medium term, *A. triquetrum* would appear to be holding its own, but in the longer term there are uncertainties. Known from only five localities with a decline in both extent of occurrence and area of occupancy it is classified as Endangered on the revised British Red List.



Acaulon triquetrum

M

ANDREAEALES

Andreaea frigida

Icy Rock-moss

VU

BAP; NR

No change

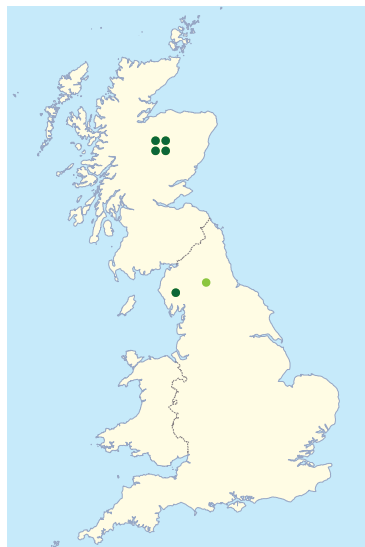
Andreaea, named after Johann Andreae, a German pharmacist (1724–1793), is a distinctive group of mosses that form small blackish to reddish cushions on rocks in the hills and mountains. The tiny capsule separates *Andreaea* from all other mosses; it opens by four longitudinal slits or valves, which remain attached at the top, and has given the group the alternative name of lantern mosses. *A. frigida* is relatively robust for an *Andreaea*, with shoots over 4 cm tall and forming cushions several centimetres across that can coalesce into extensive patches. It is monoicous and sporophytes are commonly produced during the summer months and asexual propagules are absent. It behaves as a long-lived shuttle species.

In England it inhabits NE-facing corries where the cold waters drain from higher elevations (hence its specific name '*frigida*') and where UV levels are high; the cushion growth form, to conserve moisture and dark pigmentation, are adaptations to such extreme conditions. *Andreaea* tend to show niche differentiation in relation to altitude, with *A. frigida* occupying the intermediate altitude range (in England 385–725 m a.s.l). It favours stable, sloping, acid rock surfaces, such as boulders, that are inundated or flushed intermittently or sprayed with cold ice-melt water beside waterfalls, or rocks in more open sections of streams where water drains from high corries or screes. It overlaps in its altitudinal range with *A. rothii* ssp. *falcata*, which is a frequent associate, and more rarely with *A. mutabilis* and *A. megistospora*.

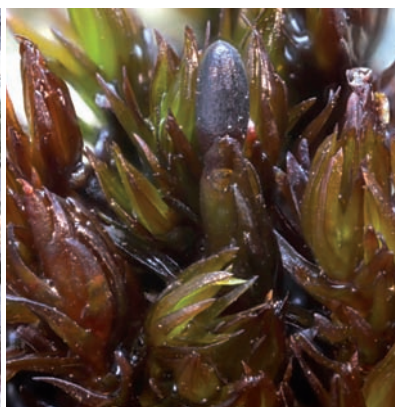
It is a European endemic and belongs to the European Boreal–montane element, extending from Norway to the Iberian Peninsula (Portugal) and east to Romania; it is considered rare throughout Europe (ECCB, 1995). In Britain *A. frigida* is known from the Cairngorms

in Scotland (first collected in 1835) and Upper Eskdale in England, in the shadow of Scafell Pike, Cumbria. It was first discovered in England in 1854 from Cronkley Scar in Upper Teesdale by A.O. Black, but it has never been re-found here despite a recent search. Nearly 100 years later, in 1952, it was found growing on the Eskdale slopes of Scafell Pike by Mrs. J. Appleyard (1906–1989), a past honorary member of the BBS. There are two other collections of *A. frigida* from England, but the identity and provenance are doubtful in both cases. In Scotland there is a strong association of *A. frigida* with areas of very late snow-lie, a situation not pertaining in Upper Eskdale today. This curious distribution in Scotland and England, given that there are apparently many suitable sites for this moss in Britain, is perplexing.

The population in Upper Eskdale is within the Scafell Pikes SSSI, which is a component of the Lake District High Fells SAC. The site was been



Andreaea frigida



ABOVE LEFT: A boulder in Upper Eskdale, Cumbria, covered with cushions of *Andreaea frigida* and splashed with ice-cold water. Photo: Nick Hodgetts.

ABOVE: *Andreaea frigida* with characteristic capsule (centre of picture). Photo: Des Callaghan.



LEFT: The locality of *Andreaea frigida*, Upper Eskdale in the Scafell Pikes, Cumbria. Photo: Nick Hodgetts

methodically surveyed in 2004 as part of the BAP (Hodgetts, 2004b) and the number of cushions are estimated to be in the order of 10,000. There would appear to be few threats to the Eskdale population, and it is not on routes used by walkers or other hill users. The presence of green algae in some of the streams may suggest eutrophication and should be kept under surveillance. How climate change will affect *A. frigida* is unknown, but since, like most British bryophytes, it has northerly affinities, it may be susceptible to a warmer climate. Despite its local abundance both at Upper Eskdale and in the Scottish Cairngorms, it is confined to just two areas and is therefore listed as Vulnerable in Britain.

M

HYPNALES

Anomodon attenuatus

Slender Tail-moss

EN

NR

No change

Anomodon attenuatus is a slender pleurocarpous moss that forms olive-green to golden-brown rough mats with primary creeping stems to 3 cm long. From these arise numerous irregular curved secondary stems, which sometimes narrow to form a flagelliform (whip-like) drooping branch with progressively smaller leaves (hence the epithet *attenuatus*). The small (less than 2 mm long) nerved leaves are broadly oval below, tapering to a blunt, weakly toothed apex, and have a matt surface due to a covering of 2–3 papillae



Bankside boulders supporting *Anomodon attenuatus* on the River Eden, Cumbria.

Photo: Ron Porley. INSET: *Anomodon attenuatus* showing the narrow attenuate branches.

Photo: Štěpán Koval (Czech Republic).

(wart-like protuberances) on each leaf cell. When dry the leaves are closely appressed to the stem and overlap, but spread when moistened. It is dioicous and sporophytes are unknown in Britain. Specialized asexual propagules are absent and it behaves as a perennial stayer.

In England the moss grows on river bank boulders overgrown by herbs, grasses and ferns, in the flood zone at about 50 m a.s.l. It occurs on sheltered vertical rock surfaces with the mosses *Homalia trichomanoides* and *Anomodon viticulosus* (a larger yellowish-green plant with untoothed leaf tips) indicating the rock is more or less base-rich, and *Brachythecium velutinum*, *Plagiochila porelloides* and *Schistidium rivulare* grow on the boulder tops. In Scotland the moss also grows as an epiphyte and on rotten wood.



Anomodon attenuatus

A member of the Circumpolar Boreo-temperate element, it is widespread throughout temperate Europe, north to Iceland, becoming montane in the south. It is also known from W and C Asia, N and C America and the West Indies. In Britain *A. attenuatus* is known from the Den of Airlee in Scotland since 1867; for a while it was thought to be extinct here until the moss was re-found in 1996. Then in 2008 it was found new to England by M. Lawley on the banks of the River Eden, near Armathwaite in Cumbria. It occurs within the River Eden and Tributaries SSSI and the River Eden SAC. For such a rare plant in Britain it is surprising that it is not on the UK BAP list and there is no specific conservation action. It is currently known from just two rocks on the Eden and further survey is needed along the main river and the many tributaries that empty into the Eden to ascertain if other colonies are present. Any threats to the population in England remain to be evaluated, but it is categorized as Endangered on the British Red List by virtue of its very small population.

M

HYPNALES

Anomodon longifolius

Long-leaved Tail-moss

VU

BAP; WCA; NR

No change

The species forms yellowish-green rough mats with shoots to 2 cm long. It is a more slender plant than *A. attenuatus* (page 51), and in fact shows a closer resemblance to other common mosses such as *Amblystegium serpens* and *Heterocladium heteropterum*. Key features are the nerved leaves which taper from a broad base to a fine point, and the very fine secondary branches that occasionally form a flagelliform (whip-like) drooping branch with progressively smaller leaves. In the dry state the leaves are appressed to the stem but spread out when moistened. It is dioicous and sporophytes are unknown in Britain. Specialized asexual propagules are absent and it behaves as a perennial stayer.



ABOVE: *Anomodon longifolius* on a vertical limestone outcrop in Germany. Photo: Michael Lüth.

RIGHT: *Anomodon longifolius* is a more delicate plant than *A. attenuatus*, with fine branches and pointed leaves. Photo: Markus Meier (Germany).



A calcicole, the moss grows on steep or vertical crags of limestone or basic sandstone, typically in lowland broadleaved deciduous wooded valleys and ravines. It occurs on humid rock ledges and under overhangs, usually where at least partially shaded. It is often associated with the more robust *A. viticulosus* and occasionally with the mosses *Neckera complanata*, *Plasteurhynchium striatulum*, *Thamnobryum alopecurum* and the liverwort *Scapania aspera*.

It belongs to the Eurasian Boreo-temperate element, and is widespread in Europe, north to Norway and south to Spain and Italy, where it is much rarer. Elsewhere it is known from the Caucasus, Siberia, Far East Russia and Japan. In Britain it was first discovered in Scotland and it also occurs in Wales. One of the earliest English records is from Ingleborough, in 1861, by bank clerk G. E. Hunt (1841–1873) but J. Nowell (1802–67) and R. Spruce (1817–1893) also collected it, from Ingleborough and Rokeby, Durham, respectively. The Revd C. H. Binstead (1862–1941) recorded it from shady rocks near Wells, N Somerset, in 1886 but it has never been seen since. The most southerly English localities today are in the Wye Valley, where it has been known since 1897 (found by H. W. Monington, 1867–1924). It has been seen here by a succession of bryologists, including visits



Anomodon longifolius

by the BBS in 1968 and 1988, and populations are known from The Slaughter and Lady Park Wood, in some of the finest stands of Beech (*Asperulo-Fagetum*) and Field Maple and lime (*Tilio-Acerion*) forests in England. Regrettably, it has been over-collected here in the past as evidenced by the large amounts in national herbaria. The area lies within the Upper Wye Gorge SSSI and Wye Valley Woodlands SAC. Farther north it occurs on a single Magnesian limestone boulder in Anston Stones Wood SSSI in SW Yorkshire, and a fine population was found by M. J. Wigginton in 1988 along the River Tees in Durham where it extends over some 600 m of Magnesian limestone outcrops along the upper river bank (unprotected). It has not been seen recently at its other historical sites in Yorkshire.

There is no specific conservation action undertaken although the plant receives full protection under the WCA 1981. The UK BAP is yet to be published but further survey to assess the status of this plant in Britain should be considered a priority. In the absence of an effective reproductive strategy, and due to its poor ability to colonize new sites, *A. longifolius* is at high risk from local extinction. Threats have not been fully evaluated but competition from other plants such as Ivy and loss of the tree canopy with a concomitant increase in sunlight and lowering of humidity levels would put some colonies at risk (Church *et al.*, 2001). Given the small number of sites in Britain, and its decline in extent of occurrence, it is categorized as Vulnerable on the revised British Red List.

M

SPLACHNALES

Aplodon wormskioldii

Carrion-moss

CR

BAP; NR

No change

This moss forms loose bright green tufts, sometimes extensive, to 5 cm tall. It has broad soft leaves with entire margins, a nerve that ends below the apex and often a bent back tip. It is monoicous and sporophytes are frequent. It is the sporophyte that provides the best field character, having a thin, rather weak, translucent seta and an erect capsule with a conspicuous neck. Asexual propagules are absent. As in other members of the Splachnales, its spores, which are sticky and adhere to each other, are dispersed by flies. It behaves as a short-lived shuttle species.

Known as one of the 'dung-mosses', it grows on carrion such as sheep, deer and other animals, or on dung, typically on wet boggy ground in the hills or mountains. Attracted by volatile octane derivatives emitted from the neck of the capsule, various kinds of fly carry the spores to other patches of dung or carrion where it can eventually cover the entire dung patch or carcass.

The plant belongs to the Circumpolar Arctic-montane element and reaches its greatest abundance in the Arctic Circle. It is almost the sole representative of a High Arctic distribution in Britain, elsewhere occurring in Svalbard, Fennoscandia, northern Russia, Arctic N America, and Greenland from where it was originally described. In the BI it is known from Scotland (first record 1905 but not seen since 1981) and was first discovered in England in 1870, on Widdybank Fell in Upper Teesdale, Durham, collected by M. B. Slater (1830–1918).

In England it has been recorded from five sites in Upper Teesdale and adjacent parts of Cumberland and Westmorland, including Yad Moss, Cross Fell, and Knock Fell, mostly in the early to mid-20th century. The last record, by T. J. Bines, was on Widdybank Fell in 1974. Most



LEFT: *Aplodon wormskioldii* cushion with numerous capsules raised on translucent setae. Photo: Blanka Shaw (Alaska). RIGHT: The sticky yellow spores of *Aplodon wormskioldii* are dispersed by flies. Photo: Lars Hedenäs (Sweden).

of its historic sites fall within Upper Teesdale SSSI (Durham) and the contiguous Appleby Fells SSSI (Cumbria), which are within the North Pennine Moors SAC. There has been much speculation as to the reasons for its decline and its apparent loss in England, including draining of bogs and afforestation, changes in animal husbandry requiring prompt removal and disposal of fallen stock, the widespread use of agrichemicals, or insect vector problems.

There is also the possibility that *A. wormskioldii* has been an early casualty of climate change. The occurrence of an Arctic species in Britain, on the southernmost latitudinal limit of its world distribution, was not anticipated (Crundwell, 1994). Some support for this theory comes from central Europe where a herbarium based study has provided evidence that bryophytes adapted to high, cool altitudes (cryophilous) are expanding their range to higher elevations in Switzerland and that at lower elevations a slow extinction process is occurring, probably as a result of climate warming trends (Bergamini, Ungricht & Hofmann, 2009). It is a UK BAP priority species and possible conservation actions include reintroduction using material gathered from Sweden; axenic cultures of *A. wormskioldii* of Swedish provenance are currently held in the *ex situ* threatened bryophyte facility at RBGK. Nonetheless, reintroduction and



Aplodon wormskioldii

other suggested actions such as ‘seeding’ remote areas of ground with carcasses to provide the specialized niche (already tried in Scotland without success, Rothero, 2003) may prove futile if indeed the species is a victim of climate change. Currently it is considered to be of extremely high risk of extinction in Britain, and is thus Critically Endangered on the British Red List.

M

POLYTRICHALES

Atrichum angustatum

Lesser Smoothcap

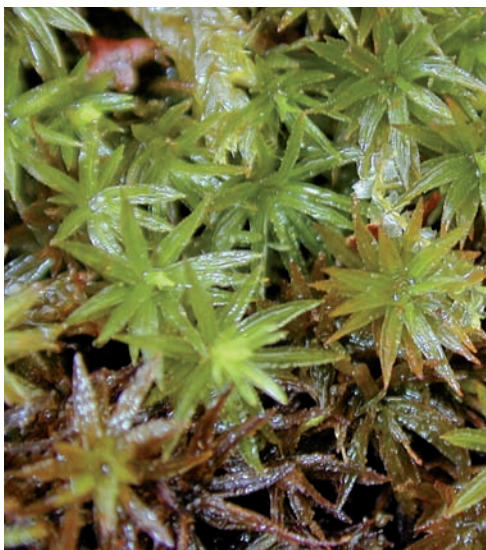
CR

BAP; NS

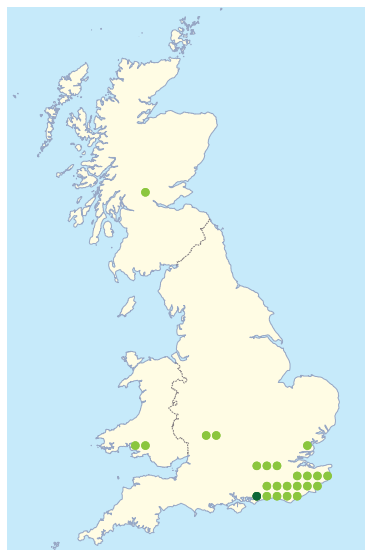
Upgraded

This species forms turfs of olive-green sometimes reddish-tinged shoots to about 2 cm tall, rarely more. The genus, once known as *Catharinea*, named under royal patronage for Catherine II of Russia (1729–1796), is recognized by longitudinal lamellae on the upper side of the nerve, a character shared by other members of the Polytrichales. The leaves, which are straight or sometimes faintly undulate when moist but curled and crisped when dry, taper from a narrow base and are distinctly toothed on the upper margins. It is easily confused with the common *A. undulatum* and its identity should be confirmed microscopically. It is dioicous and sporophytes with the characteristic smooth calyptra or cap (*Atrichum* means without hairs, referring to the calyptra) are rare. Specialized asexual propagules are not known in Britain, but rhizoidal tubers have been reported from Austria. It behaves as short-lived shuttle species.

In England it is a plant of mildly acid loamy or sandy soil of tracks, rides and paths in ancient woodland, favouring sites that are in dappled shade and damp throughout the year,



Atrichum angustatum, a rapidly declining species, photographed in Sussex. Photo: Ron Porley.



Atrichum angustatum

both on level ground and on gently sloping banks and sides of ruts. It occurs with a range of other bryophytes including *A. undulatum*. The majority of records are from the High Weald but also in woodlands on the loamy greensand of the Hythe Beds and on clay-with-flints on the North Downs plateau. Over the years the plant has inexplicably disappeared from its characteristic woodland habitat and is today known as a colonist of disused sandpits.

A member of the European Temperate element, it is scattered through much of Europe north to Iceland and east to Russia. Elsewhere it is known from the Azores, Madeira, Turkey and eastern N America where it is relatively common. In the BI it was formerly known from Ireland, Scotland and Wales and from eight English counties, mainly in the SE Kent and Sussex have always been its centre of distribution in Britain, elsewhere its occurrence is sporadic and possibly non-persistent. It has been known in England since at least 1846, when W. Mitten (1819–1906) collected it at Hassocks, near his home at Hurstpierpoint. In the *British Moss Flora* (Braithwaite, 1887) it is given as very rare, whereas some 60 years later, in the 3rd edition of the *Student's Handbook* (Dixon, 1954), it was said to be '*not rare in Sussex*', and Rose (1951) describes it as not uncommon in the High Weald of Kent and Sussex. In 1961, the BBS gathered it in Bedgebury Forest but its presence did not elicit any special comment. In Surrey it was known to occur at four sites but was last seen in 1910; the compiler of the Surrey flora (Gardiner, 1981) observed that it may possibly be extinct in the county but did suggest that more probably it is rare and overlooked. Over a period of about 100 years or so, it went from a locally abundant plant (hence listed as Nationally Scarce) to one with abruptly diminishing records. There are very few records after 1970 and the last known population apparently disappeared very soon after 2000.

At its last known location, Slindon, near Arundel in W. Sussex, a small population grew in a disused sandpit scattered over an area of about 150 cm². It occurred on a south-facing sandy bank under a light canopy of birch, oak, Hazel and Sycamore amongst a grassy ground flora with herbs and a range of other mosses including *A. undulatum*. Sporophytes were never reported here, and the sex of the plants was unknown. The site has no designation.

The reasons for the marked decline from its former strongholds including the High Weald are mystifying. It has been suggested that it is simply overlooked, but recent surveys have failed so far to find the plant. Whether the apparent decline can be attributed to changes in management of the woodland habitat, to atmospheric pollution, or is related to the population dynamics of the plant, is uncertain. Another possibility is it was over-recorded in the past; herbarium material should be checked. The species is contained within the Temperate element, a group not expected to be overly sensitive to climate change (Bates & Preston, 2011). A clue to the possible cause may lie in its reproductive biology. Capsules are rare and plants are usually sterile in this dioicous species, although on occasion it has been reported to fruit abundantly (Rose, 1951). Rarity may therefore be due to spatial sexual segregation – in several places the species appears to consist of male only colonies. For fertilization to occur male and female colonies must grow close to each other as gamete dispersal can only operate over short distances. Vegetative expansion of same sex clones may further increase the distances (Wyatt, 1977). Given the rapid and steep decline in Britain the risk of extinction was raised from Endangered (Church *et al.*, 2001) to Critically Endangered in the revised British Red List, but this was too late to galvanize action to prevent it slipping closer to extinction. Nevertheless, extinction is hard to verify, and it is a matter of some urgency that a national targeted survey is undertaken.

*Bruchia vogesiaca***Vosges Candle-moss**

CR

H&S; NR

Upgraded

This minute moss, the specific epithet referring to its original collection from the Vosges Mountains in France, forms scattered turfs or solitary shoots to 3 mm tall (including capsules, up to 7 mm). The leaves are expanded at the base and taper gradually to a long thin leaf tip composed largely of an excurrent nerve. It is monoicous and sporophytes are common, often providing the only clue to the presence of this easily overlooked moss, and show the distinctive swollen neck region characteristic of the genus. Filamentous gemmae on a persistent protonema have been reported from Portugal (Sérgio, Jansen & Séneca, 1998) but are unknown in British plants. The high investment in sexual reproduction, relatively large spores (>20 µm) and gemmae in the juvenile (protonemal) stage, corresponds to the life-history strategy of a short-lived shuttle species.

In the British Isles, this moss occurs only along the banks of a small river flowing through semi-improved cattle-grazed damp acid grassland. It grows on well-illuminated, more or less vertical gritty humic soil above normal water level and is prone to scouring and flooding. It is intolerant of competition and those plants that do share the same niche are low growing bryophytes including *Atrichum tenellum*, *Dicranella rufescens*, *Pellia epiphylla*, *Pohlia campototrachela* and *P. melanodon*.

Bruchia vogesiaca is known from a belt extending from Austria through southern Germany, France and Spain to central Portugal. Elsewhere it is known from a few localities in N America and a single record in China. It is very rare throughout its range, often known from a single locality within a country and the records are often very old. It is endangered



ABOVE: *Bruchia vogesiaca*, a globally rare species listed on Annex II of the Habitats & Species Directive. Photo: Michael Lüth (France). RIGHT: *Bruchia vogesiaca* in Cornwall, showing the enlarged swollen neck region at the base of the capsule. Photo: David Holyoak.





The stream bank habitat of *Bruchia vogesiaca* on Bodmin Moor, Cornwall. Photo: Ron Porley.



Bruchia vogesiaca

in Europe (ECCB, 1995), known only from about 20 localities, and is listed on Appendix I of the Bern Convention and on Annex II of the H&S Directive. The discovery of this species in 2006 by D. T. Holyoak on the western edge of Bodmin Moor, E Cornwall at an altitude of about 230 m, was a most unexpected but exciting find (Holyoak, 2007). Initially, only four plants with capsules were seen but a visit a week or two later revealed an additional seven plants, all within about 1.5 m of each other. A later search re-found the original colony and about nine capsules were seen, and some 30 m farther downstream four more plants, two with capsules, were discovered. This gives some optimism that it may occur in other places, either along the same watercourse or farther afield. Bodmin Moor is remarkable for its low altitude supporting upland communities with Atlantic elements in the flora and fauna. How long *B. vogesiaca* has been on Bodmin Moor is unknown, but its presence as a glacial relict is a possibility (Sérgio, Jansen & Séneca, 1998).

Threats have yet to be fully evaluated but such a small population is potentially vulnerable. Cattle seeking access to water or to adjoining pastures regularly cause sections of bank to collapse, and erosion is further exacerbated by horse riders crossing the river very close to the site, resulting in the loss of the steep-cut river profile. The habitat where it grows in other parts of Europe is also grazed by cattle, and such disturbance probably provides the open conditions that this short-lived shuttle species requires. It is, however, a fine balance and extreme disturbance can potentially lead to extirpation. Excessive nutrient input and changes in water quality and quantity could also be factors impacting it (Sérgio, Jansen & Séneca, 1998).

The Cornish population lies within the Bodmin Moor North SSSI. Furthermore, the listing of a species on Annex II of the H&S Directive requires sites to be listed as candidate SACs and all EU Member States are required to report on the conservation status of listed species on a six-yearly cycle. *Bruchia vogesiaca* is on the revised British Red List as Critically Endangered in recognition of the population comprising less than 50 individuals.

*Bryum calophyllum***Blunt Bryum**

VU

BAP; NR

No change

This is a small, pale, olive-green to pinkish turf-forming moss with shoots to 15 mm tall. The name *calophyllum* is derived from the Greek meaning 'beautiful leaves' and refers to the delicately coloured, ovate concave leaves with a blunt or shortly pointed apex, a feature that sets this species apart from most other members of this taxonomically difficult genus (but see *B. marratii*, page 65). It is monoicous with nodding capsules held on straight setae. Specialized asexual propagules are unknown. It behaves as a short-lived shuttle, with high investment in sexual reproduction and production of large spores (26–42 µm), a strategy characteristic of rather persistent micro-sites.

It is a plant of coastal dune slacks, sandy foredunes and occasionally on moist sand in estuaries. It grows on damp, open calcareous sand, disappearing if closed stable vegetation develops. It depends on active erosion caused by wind-blow or grazing by sheep or rabbits to produce gaps for colonization and populations fluctuate in response to these factors.

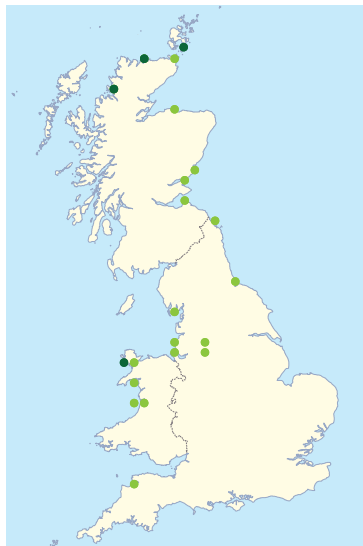
A member of the Circumpolar Wide-Temperate element, *B. calophyllum* is widespread but listed as rare in Europe (ECCB, 1995) and has shown a marked decline throughout its southern range limits. It is reported from Iceland, Svalbard, Faeroes, Norway, Sweden, Finland, Latvia, Estonia, northern Russia, occurring sparsely farther south in The Netherlands, Germany (extinct), Denmark, Poland and Romania. Elsewhere it is reported in Arctic and subarctic regions of Asia, N America and Greenland. In the BI it has been recorded from Ireland (four localities), Scotland (three localities), Wales (one locality) and England. The date of the first English record is uncertain, but we do know that it was collected by the Liverpool conchologist and mineralogist F. P. Marrat (1820–1904) at Ainsdale Sands on the Sefton Coast in S Lancashire and was new to the British flora. There was clearly a thriving population of the species in the late 19th century at Ainsdale, and it was collected many times by a succession of bryologists such as D. Moore (1807–1879) in 1840, J. H. Davies



LEFT: *Bryum calophyllum* with nodding capsules which are about twice as long as wide.
RIGHT: The olive-pinkish shoots of *Bryum calophyllum* showing the blunt-tipped, concave leaves. Photos: David Holyoak (Ireland).

(1838–1909) and W. Wilson (1799–1871) in 1854, J.B. Wood (1813–1890) in 1858, G.E. Hunt (1841–1873) in 1865 and J.A. Wheldon (1862–1924) in 1894. It continued to be collected into the 20th century, for example by H.N. Dixon (1861–1944) in 1908, but by the 1930s the records were in decline, and the last record, at Ainsdale and also in England, was made by M.J. Wigginton in 1983.

There are historical records for *B. calophyllum* in N Devon (last record 1900), Cheshire (1903), NE Yorkshire (1896), Durham (1905), N Northumberland (1924) and Westmorland where it was last seen at Sandscale Haws in 1969. It was known from seven sites in England, but searches by D. T. Holyoak in 2001, on behalf of Plantlife and EN/NE under the UK BAP, failed to find the plant at any of its historical localities. It is possible that it has been overlooked, and the Sefton Coast in particular, designated as an SSSI and SAC, offers considerable scope for this plant since active erosion and accretion of sand still occurs here.



Bryum calophyllum

The apparent loss from England can largely be attributed to habitat degradation from development, recreational pressures such as golf, trampling and vehicular access, dune stabilization for silviculture and agriculture, lowering of water tables, coastal protection works, vegetation succession and lack of grazing. The Ainsdale to Southport dunes (Sefton Coast) have been famous for rare coastal *Bryum* for some 150 years and scores of collections were deposited in private and public herbaria. It is not unreasonable to suggest that over-collecting may also have taken its toll.

Future work under the UK BAP should include incorporation of material (sourced from other parts of Britain) in the *ex situ* threatened bryophyte facility at the RBGK; reintroduction should be considered within the context of IUCN translocation guidelines. If natural coastal processes such as sand accretion and erosion are no longer occurring, consideration should be given to scraping vegetation from small areas. The species is listed as Vulnerable on the British Red List on the basis that there has been a definite decline in extent of occurrence, area of occupancy, population size and habitat quality and it occurs in fewer than ten locations.

M

BRYALES

Bryum gemmiparum

Welsh Thread-moss

EN

BAP; NR

No change

This is a moderately sized dull to olive-green turf-forming moss, reddish in the lower parts, with densely packed shoots to 3 cm tall. The leaves are held close to the stem when dry, but spread widely when moist. They are oval and distinctly concave, with a thick nerve that ends

in the leaf apex. It is dioicous and sporophytes are unknown in Britain. It has specialized asexual propagules in the form of green to reddish bulbils clustered amongst the upper leaves, and orange to pinkish spherical tubers are sometimes present on short rhizoids. It is said to be a colonist, with a high investment in asexual reproduction. The relationship of *B. gemmiparum* with other non-European *Bryum* is uncertain, and only plants with the characteristic bulbils can be confidently named.

It is an aquatic moss growing in rock crevices in the beds of lowland streams and rivers in the littoral zone, by cascades or where there is some silt deposition. It may grow either submerged or exposed when water levels are low. It sometimes occurs with other aquatic bryophytes such as *Cinclidotus fontinaloides*.

A member of the Mediterranean–Atlantic element, it is predominately a southern European species, widespread around the Mediterranean region and the Balkan Peninsula. It extends north to Germany and Switzerland, but due to taxonomic uncertainties the precise range is unknown. Elsewhere it has been reported from Turkey, Cyprus, Ukraine, Georgia, Azerbaijan, the Canary Islands and N Africa. In the BI it is known from Ireland, Wales and England. The date of the first English collection is uncertain, but it was collected by W. Watson (1872–1960) from Compass Cove, on the south Devon coast near Dartmouth. It has never been seen there since. In 1961, it was found by T. Laflin (1914–1972) on the N Devon coast on stones in a small stream at Welcombe Mouth. J. Appleyard (1906–1989) also gathered it here in 1970, and it was last seen during a BBS meeting in 1982. It was also reported near Malmsmead, about 2.5 km from the coast along the East Lyn River in



The swelling tufts of *Bryum gemmiparum* on wet rocks. Photo: Michael Lüth (Greece).

INSET: *Bryum gemmiparum* with gemmae clustered within the upper leaves (top left).

Photo: David Holyoak (Ireland).

N Devon during another BBS field meeting in 1971. Some doubt was subsequently expressed over the identity of these plants (Smith, 2004). Nonetheless, in 2010 material was collected by B. Averis from the same river some 7 km farther west near Lynton (outside the nearby Watersmeet SSSI). DNA sequencing at RBGE placed it within *B. gemmiparum*.

The reasons for the decline of the plant in England are unknown although pollution and nutrient enrichment are two possible factors. However, species with narrow habitat specificity tend to be rarer than those with more catholic requirements (Cleavitt, 2005); any perturbation to the niche could thus be catastrophic. It may not be coincidental that the Welsh river that supports *B. gemmiparum*, the River Usk, also supports three kinds of lamprey, two kinds of shad and spawning Atlantic Salmon. These organisms epitomize high water-quality and an unmodified natural river system. Habitat loss due to river engineering work has been cited as a possible threat (Church *et al.*, 2001). Dispersal is dependent upon asexual reproduction, including fragmentation, which must diminish the chances of the moss establishing in new sites. The species was added to the UK BAP in 1997 but there is as yet no published Action Plan. Targeted survey of historic sites, including neighbouring watercourses, is a priority. Consideration should be given to the inclusion of material from Lynton into the *ex situ* threatened bryophyte facility at the RBGK. Given that it has a very restricted range with fluctuating populations in Britain, it is classified as Endangered on the revised British Red List.



Bryum gemmiparum

M

BRYALES

Bryum knowltonii

Knowlton's Thread-moss

VU

BAP; NS

No change

This species, named in honour of T. Knowlton (1692–1782), botanist and gardener to the Earl of Burlington, is a small pale green to reddish turf-forming moss with shoots to 10 mm tall. Its oval, slightly concave leaves have a reddish base with a nerve that runs into the pointed leaf apex. It is monoicous and sporophytes are common. The naming of many *Bryum* can be difficult and mature capsules are necessary for the unambiguous identification of *B. knowltonii*. Specialized asexual propagules are unknown in nature although filamentous protonemal gemmae have been produced in culture. This moss behaves as a short-lived shuttle species, characteristic of moderately persistent niches.

It is a species of calcareous dune slacks where it colonizes bare damp sand, often with other low mosses amongst a sparse covering of herbs and grasses. It also occurs on sandy patches in upper saltmarsh, often amongst rushes. Occasionally it is found inland on sandy ground



Bryum knowltonii in Northumberland, showing the reddish leaf base and a nerve that ends in a pointed leaf apex. Photo: David Holyoak.



Bryum knowltonii

of gravel pits and quarries. Associated bryophytes include *Hennediella heimii* and *Tortella flavovirens*.

A member of the European Boreal–montane element, this moss is discontinuously circumpolar and in Europe occurs from Svalbard, Iceland, Faeroes and Scandinavia, through central Europe and east to the Balkans. Elsewhere it is known from Siberia, Himalaya, China, Alaska, Canada and Greenland. In the BI it occurs in Ireland, Scotland, Wales and England. One of the earliest collections was made in England in 1804 by lawyer and County Court judge F.K. Eagle (1784–1856) at Wangford in Suffolk, on sandy deposits some distance from the coast. It was probably seen again here in 1807, but hereafter there are no more records.

It is predominately an English species, recorded from 18 English vice-counties and about 32 localities (it is difficult to be precise about localities since site names, particularly historic sites, were not used consistently and are often poorly localized). In many counties it has been recorded only once, but numerous records originate from the Sefton Coast, the largest sand dune system in England. Here, the earliest record dates from around 1855 at Ainsdale, collected by F.P. Marrat (1820–1904), the Liverpool bryologist who took a special interest in *Bryum* and who is commemorated by *B. marratii* (page 65). Many other 19th century collectors were clearly familiar with this species along the Sefton Coast, including J.A. Wheldon (1862–1924) who contributed many records from S Lancashire and neighbouring counties. The great German bryologist W.P. Schimper (1808–1880) was drawn to the Southport area of the coast in 1860 and duly collected the plant. By the beginning of the 20th century records from the Sefton Coast were declining, and the final record was made by J.A. Wheldon in 1917. This was not however the last record for Lancashire; in 1977 it turned up at Pennington Flash Country Park, Greater Manchester, collected by M.E. Newton.

Records of *B. knowltonii* from the extensive dune system on the N Lincolnshire coast date back to 1899 and continue sporadically through to the 1930s, but the next record, near Humberston, was in 1965, by the County Recorder Prof. M.R.D. Seward. It was re-found in 2001 by

N.G.Hodgetts at Saltfleetby. Other post-2000 records derive from the N Northumberland coast, in particular on Holy Island, where D.T.Holyoak has recorded it from 2000 through to 2008 in numerous small patches on damp humic sand on the edge of a saltmarsh, and D.E.McCutcheon found another population on Primrose Bank on Holy Island in 2009. It was also found in Norfolk, in a foredune slack at Burnham Overy Staithe, in 2003.

The reasons for the decline include habitat loss, development, recreational pressures, dune stabilization, drainage, vegetation succession and slacks becoming overgrown (lack of grazing) and, at inland sites, infilling of sand pits, drainage and tipping. Over-collecting in the past may also have been a contributory factor judging from the copious specimens in herbaria. Populations in sand pits and quarries tend to be impermanent, whilst those on active coastal dune systems show greater persistence. With the exception of targeted survey work on rare coastal *Bryum* carried out in the early 2000s, there is no specific conservation action aimed at this species. Following field survey, a leaflet was prepared that provides advice to landowners on how to care for threatened dune slack bryophytes (Plantlife International, 2003).

All post-2000 populations lie within SSSI/SACs (Lindisfarne SSSI/N Northumberland Dunes SAC, Saltfleetby-Theddlethorpe Dunes SSSI/ Saltfleetby-Theddlethorpe Dunes and Gibraltar Point SAC and North Norfolk Coast SSSI/SAC). These sites provide active slack formation and windblown sand accretion required by the species. Further survey is desirable to locate historic or new populations, particularly on saltmarsh edges, and existing populations should be monitored. Given that its range is restricted and has clearly declined, and that populations fluctuate, it is classified as Vulnerable on the revised British Red List.

M

BRYALES

Bryum marratii

Baltic Bryum

VU

BAP; NR

Downgraded

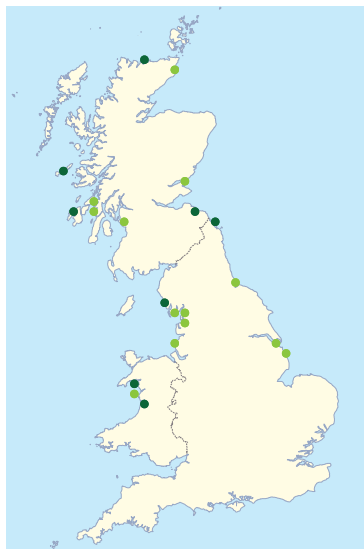
This species, named after its discoverer the mineralogist, conchologist and bryologist F.P.Marrat (1820–1904), is a small bright green turf-forming moss with shoots 2–10 mm tall. The strongly concave oval leaves, with no tinge of red at the base, are blunt tipped. It is monoicous but capsules are not common. The shape of the capsule (short with a pronounced pointed lid) is the best character to separate it from *B. calophyllum* (page 60). Specialized asexual propagules are unknown in the wild or in culture, a factor which may in part account for its rarity (Duckett *et al.*, 2004). However the fragile shoot tips break off readily and may function as vegetative propagules. It behaves as a short-lived shuttle species.

It is primarily a plant of the margins of upper saltmarsh, only rarely occurring in dune slacks (this contrasts with its habitat in the 19th century, where many records were from sandy ground on the coast). It occurs on weakly saline substrates, on moist or wet silty or clayey mud, often in sites that receive intermittent flooding during high water or river overflow.

A member of the European Boreal–montane element, it is rather rare throughout its range and its status in Europe and elsewhere is in need of revision. It is listed as regionally threatened in Europe (ECCB, 1995) and is known from Iceland, Norway, Sweden, Denmark, Finland, Latvia, Estonia, Poland, Slovakia, Germany, The Netherlands and France (in most countries there are very few populations and/or large declines have been reported). Elsewhere it



Bryum marratii showing the characteristic oval, concave and blunt-tipped leaves lacking any hint of red colour. Photo: David Holyoak.



Bryum marratii

has been reported from Asia (Altai Mountains) and N America. In the BI it shows a more northerly range than the other rare coastal *Bryum* and occurs in Ireland (numerous recent records), Scotland, Wales and England. One of the earliest English records is attributed to its namesake, in 1854, from a sandy shore at Southport, Lancashire (there is also an anonymous 1853 specimen). Marrat was one of many 'gentleman botanists' from the urban middle-class that were able to take advantage of the emerging railway network to make day-trips to botanical sites of interest. A few days later W. Wilson (1799–1871) gathered the plant from the same locality, and it was he who described the plant new to science. Over the next 35 years it was collected from a number of localities along the Sefton Coast between the Mersey and Ribble estuaries, but the last collection of *B. marratii* from this area, and indeed from S Lancashire, was made by J. R. Edmondson in the 1980s.

Old records of *B. marratii* exist for the N Lincolnshire coast, from Saltfleetby (1924) and the Cleethorpes area (1919) collected by the carpenter G. H. Allison (1862–1956), and it was last recorded here in 1965 by Prof. M. R. D. Seward. In the early 1900s it was recorded from the sands around Morecambe Bay, from Heysham to Carnforth in W Lancashire by the chemist A. Wilson (1862–1949) and J. A. Wheldon (1862–1924), and by an anonymous collector in 1980. It was also recorded in NE Yorkshire, at Coatham Marshes, by R. Barnes (1851–1918) in 1891, a site that also once supported *B. knowltonii* (page 63); the last record from here is 1898.

In total, the plant has been recorded from six English vice-counties and about eight localities. Today it is known from just two sites in England: Drigg on the Cumbrian coast and Holy Island in N Northumberland. The Cumbrian record was made by Revd A. Ley (1842–1911) in 1881 but a search by D. T. Holyoak in 2001 failed to re-find the moss. A different strategy was called for. In the late 1800s Revd. Ley would have arrived by train, alighted at Drigg station and set off on foot towards the estuary, so DTH took the same route and was rewarded by finding scattered patches of the plant near the bank of the tidal

River Irt on the saltmarsh edge, associated with another great rarity, *B. salinum* (below). The second extant population in England was also found by DTH on The Snook on Holy Island in N Northumberland in 1999 and was re-found in 2000 by D. G. Long.

The reasons for its decline include disturbance, development, cessation of grazing and changes to foreshore physiognomy. Whilst the population on Holy Island is small and ominously vulnerable, the population at Drigg does not appear to be immediately threatened. The English populations lie within two SSSI/SACs (Lindisfarne SSSI/N Northumberland Dunes SAC and Drigg Coast SSSI/SAC) and, although there is no specific conservation action, the populations should be kept under surveillance and monitored at least once every five years. Recent discoveries of new populations in Britain (but still fewer than ten locations) have resulted in its downgrading from Endangered to Vulnerable on the revised British Red List.

M

BRYALES

Bryum salinum

Saltmarsh Thread-moss

EN

BAP; NR

Upgraded

This plant is a small yellowish-green turf-forming moss with shoots to 15 mm tall. The leaves, reddish at the base with recurved margins, are narrowly oval and abruptly taper to a point from which a strong nerve extends. The upper leaves are closely packed forming a conspicuous tuft at the shoot tip. It is monoicous and the narrow pear-shaped nodding capsule has a distinctive reddish mouth; certain identification requires examination of the peristome teeth of ripe capsules. The species is very closely related to the widespread *B. archangelicum* and intermediate plants are known; the precise taxonomic status of *B. salinum* needs investigation. The Latin *salinum* means salt-cellar, and may possibly allude to the shaking out of the spores from the mature capsules rather than its inclination for saline soils. Specialized asexual propagules are unknown and it behaves as a short-lived shuttle species characteristic of moderately persistent niches.

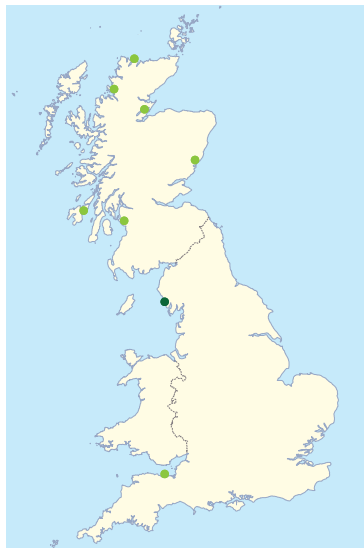
It occurs on soils that have some saline influence but where summer rainfall is sufficient to prevent excessive build up of salt, such as on the upper margins of saltmarsh, often where the ground is poached by cattle, amongst low grasses and sedges, occasionally in the zone inundated by incursion of sea water during high-water spring tides. Bryophyte associates are few in such extreme environments but may include *Amblystegium serpens*, *Leptodictyon riparium*, *Bryum algovicum* var. *rutheanum* and, at one site, the Red Listed *B. maritimum* (page 65).

A member of the European Boreo-Arctic Montane element, it is predominately coastal from Denmark north to Svalbard and Iceland and in salty meadows in Poland. Elsewhere it is known from Canada, Alaska and Greenland. In the BI it occurs in Ireland (one post-2000 record), Scotland and England. The earliest known English record is 1925, from Blue Anchor on the N Somerset coast near Minehead, found by D. G. Catchside F.R.S (1907–1994). Catchside was only 18 and still at grammar school in London when he collected the plant, but he was already totally immersed in natural history mixing with such bryological mentors as H. N. Dixon (1861–1944) and W. R. Sherrin (1871–1955) and a young P. W. Richards (1908–1995). The true identity of Catchside's plant did not come to light for



Bryum salinum with pendulous capsules.

Photo: Michael Lüth (Iceland).



Bryum salinum

another 30 years or so, when a collection of *B. salinum* in Ireland in 1957 triggered a re-evaluation of herbarium material (Nyholm & Crundwell, 1958). It has never been re-found at Blue Anchor. A visit in 2000 confirmed that this area of the N Somerset coastline has seen many changes including sea defence work and drainage and the plant was presumed extinct in England.

Extinction of a bryophyte is understandably hard to prove and, for a critical *Bryum*, even more so. In 2000 the search for another rare coastal species, *B. marratii* (page 65), took D.T.Holyoak to the Cumbrian coast at Drigg where it had been recorded in 1881. The precise location of *B. marratii* was unknown and some time was spent searching the ‘wrong’ spot. But this was not wasted time. On the NW bank of the River Irt, about 0.5 km south of Drigg church, substantial patches of a dull coloured *Bryum* with capsules were found. Subsequent microscope study revealed it to be *B. salinum*. DTH returned to the estuary in 2011 to assess the status and discovered many more colonies to the S of Drigg, on sheep- and cattle-grazed saltmarsh edge. It formed low partly sand covered turfs of mainly non-fertile shoots, although a few patches had ripe capsules.

The reasons for its decline include habitat loss, development and changes to foreshore physiognomy. It was added to the UK BAP in 1997 and, apart from the survey of rare coastal *Bryum* between 2000 and 2001, there are no specific conservation measures aimed at the moss. Nevertheless, the strong population at Drigg appears secure and not immediately threatened. It is within the Drigg Coast SSSI/SAC and should be kept under surveillance and monitored at least once every five years. Consideration should be given to including it in the *ex situ* threatened bryophyte facility at RBGK. In view of its very restricted range and fluctuating populations its status has been upgraded from Vulnerable (Church *et al.*, 2001) to Endangered on the revised British Red List.

*Cephaloziella baumgartneri***Chalk Threadwort**

EN

BAP; NR

No change

This species, named in honour of the Austrian bryologist Julius Baumgartner (1870–1955), is a minute blackish-green leafy liverwort with bi-lobed leaves, with shoots to 7 mm long and less than 0.5 mm wide. When present as solitary creeping shoots it can be hard to spot, but it often forms thread-like mats. Its identity must be confirmed microscopically, but it is the only British member of the genus confined to calcareous substrates and it never has any reddish pigmentation. *C. baumgartneri* is monoicous and sporophytes are fairly frequent. It produces asexual propagules in the form of tiny smooth ovoid gemmae on the leaf margins and shows a colonist life-history strategy.

It occurs in warm, sheltered situations invariably close to the sea on limestone, chalk or calcareous greensand. It grows on moist calcareous rocks in sheltered screes, half-buried stones and on thin soil, in such habitats as abandoned quarry floors and in short turf on sea cliffs. It does not tolerate direct competition but sometimes occurs on sites supporting other Red List bryophytes, such as *Acaulon triquetrum* (page 47), *Plasteurhynchium meridionale* (page 147) and *Southbya nigrella* (page 165).

A member of the Mediterranean–Atlantic element, it reaches its most northerly world stations in Belgium, England and The Netherlands. Although a rare plant in global terms, it is not threatened in Europe; it is frequent in the Mediterranean region and extends eastwards to Turkey. Elsewhere it is known from Israel, N Africa and Macaronesia. In the BI the species is confined to the warm southern counties of England, from Dorset to Kent. The stronghold in England is on the Isle of Portland SSSI and the adjacent Nicodemus



The tiny, almost black leafy liverwort *Cephaloziella baumgartneri* creeping over limestone. Photo: Ron Porley (Portugal).



Cephaloziella baumgartneri

Heights SSSI, Dorset, which are also designated as a SAC. It was discovered here by W.E. Nicholson (1866–1945) in 1921 and recent survey work has shown it to occur in about 15 localities, mostly on quarry floors and in open grassland on coastal cliffs. Historic and modern day land uses on Portland have resulted in a complex mosaic of habitats that are variously threatened by neglect, recreation, development, quarrying and invasive plants including *Cotoneaster* and *Buddleja*. *Cotoneaster* dominance is a serious problem, and a programme of eradication in certain units of the SSSI was undertaken by EN (now NE) with some success. A small group of feral goats was introduced to an area of cliff in 2007 on a trial basis, which has helped to control scrub regrowth to some extent. Although not aimed specifically at *C. baumgartneri*, these measures do benefit this species and other Red List bryophytes by providing short open turf.

A strong population is also present on the calcareous greensand of St. Catherine's Point IoW, within the Compton Chine to Steephill Cove SSSI. Known here since 1964, it grows on soft limestone boulders within an area of unstable landslip. In both the Dorset and IoW sites, grazing by rabbits and undercliff erosion and landslip provides the conditions for population maintenance and spread. The plant was also recorded recently (2002) in Lydden and Temple Ewell Downs SSSI near Dover in E Kent, bringing the total known occurrences in SSSIs to four.

Its Sussex sites have not fared so well. One of the earliest finds of this plant in Britain was from downs just S of Lewes, E Sussex, collected by W.E. Nicholson in 1901, but there are no recent records. Since 1909 it has been known from a chalk cliff at Swanbourne Lake near Arundel in W. Sussex but the last record here was 1985, its disappearance possibly linked to encroachment by Ivy (Church *et al.*, 2001). It has also apparently disappeared from its only known Surrey locality, at Box Hill, where it was last seen in 1955 by E. C. Wallace (1909–1986). It is likely that the species has declined due to a lack of grazing and encroachment of scrub, particularly away from the coast where landslip and coastal erosion helps to maintain open ground. Climate change may be beneficial to this species if warmer, drier summers and milder, wetter winters prevail. Given that it has clearly declined in Britain, with few locations and a low area of occupancy, it is listed as Endangered on the revised British Red List.

L

JUNGERMANNIALES

Cephaloziella dentata

Toothed Threadwort

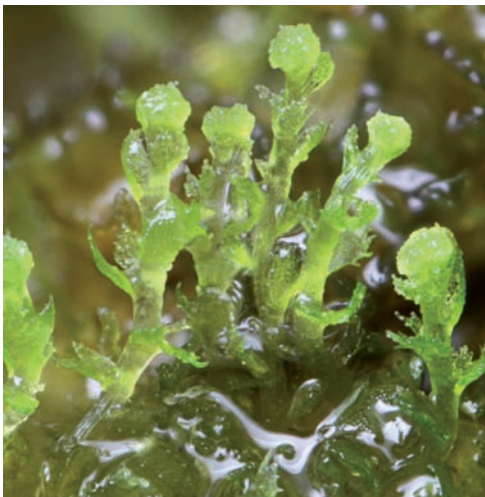
CR

BAP; NR

No change

This species is a tiny leafy liverwort, varying from yellowish-green through to reddish-brown, forming solitary creeping shoots up to 8 mm long and about 0.6 mm wide. The specific epithet refers to the toothed (dentate) leaf lobes, a feature nevertheless shared by a number of other species including *C. massalongi* (page 74) and *C. nicholsonii* (page 75). This species is dioicous, and male inflorescences and sporophytes are unknown in Britain. Specialized asexual propagules are commonly produced on the leaf margins and shoot tips; these gemmae are diagnostic in being heavily invested with wart like projections. It behaves as a colonist.

It is a species of open heathland overlying ultra-basic serpentine rock (magnesium predominates over calcium). It occupies a very narrow niche: damp open tracks, ruts



Cephaloziella dentata photographed on the Lizard Peninsula, Cornwall, showing the toothed leaf lobes: Photo: Des Callaghan.



Cephaloziella dentata

and winter-flooded hollows on base-rich nutrient poor soils with a pH of 5.5–7.5. Other *Cephaloziella* spp. (including *C. stellulifera*) and filamentous algae are sometimes found as associates.

A member of the Oceanic Southern–temperate element, it shows a western bias in Europe and is not considered threatened, but is regarded as globally rare (Laaka-Lindberg, Hedderson & Longton, 2000). Elsewhere, it is reported from Madeira, western N America and Asia. In the BI it is known only from England, on the Lizard Peninsula in Cornwall. The earliest English record is 1926, found by the indefatigable W.E. Nicholson (1866–1945), a Sussex bryologist who spent the last few years of his life at Mullion on the Lizard, one of his favourite haunts. It was subsequently recorded from a few sites on the Peninsula between the late 1920s and early 1930s, mostly by Nicholson on Lizard Downs. There followed a fallow period until J. A. Paton turned it up in the early to mid-1960s and it was last reported in 1968 near Ruan Pool. It has apparently always been very rare, often occurring in small quantity; it has been searched for on many occasions since 1968 at its former historic localities and it was beginning to seem that it had disappeared. Then, in March 2004 on E Lizard, D. T. Holyoak discovered a small population in a recently grazed, sparsely vegetated winter-flooded hollow of a long-abandoned quarry amongst serpentine rocks; it was still present in small amounts in 2012. The location, west of Rosuick, in a previously bryologically unrecorded 10 km square, is within Goonhilly Downs SSSI and the Lizard SAC.

It is not certain why this plant has declined but its confinement to a narrow niche and changes in heathland management are probably major contributory factors. The carts that once regularly traversed the Lizard heaths are all but gone and many of the tracks and ruts are no longer maintained and some are filled-in. A significant problem is cessation of grazing and frequent fires leading to a vegetation type dominated by Purple Moor-grass and gorse. The species is intolerant of competition or shading, and former open ground at one of its historic localities, Ruan Pool, has now been taken over by *Campylopus introflexus* (Porley

& Hodgetts, 2005), an invasive alien moss from the southern hemisphere. It is critical that short diverse heathland vegetation is promoted through grazing, and that hollows and tracks are monitored to ensure they remain open. Given its small extent and decline in habitat quality *C. dentata* is scheduled as Critically Endangered on the revised British Red List.

L

JUNGERMANNIALES

Cephaloziella integerrima

Lobed Threadwort

VU

BAP; NR

No change

This leafy liverwort is exceedingly small, even by the standards of *Cephaloziella*, with leafy shoots up to 4 mm long and 0.5 mm wide. It can form thin, smooth mats but more commonly it is found as solitary creeping shoots, thus is easily overlooked. The margins of the leaf lobes lack teeth, contrasting with *C. massalongi* (page 74) and *C. nicholsonii* (page 75). It is monoicous, although sporophytes are rare. Specialized asexual propagules are commonly present in the form of multi-angular gemmae on the margins of the upper leaf lobes. It behaves as a colonist.

All recent records are from old mine spoil, over sandy, clayey or rocky soil, on former mine sites and in sand dunes; older records for this species are from rabbit-grazed lowland heath and on bare patches of damp sandy soil. It is intolerant of excessive shade but sometimes grows amongst the shelter afforded by gorse and heather, often with other low growing



The reddish-brown shoots of *Cephaloziella integerrima* with perianths. Photo: Des Callaghan.

bryophytes such as *C. stellulifera* and *Pohlia annotina*. It occurs in a vegetation type known as Calaminarian grassland, a habitat listed on Annex I of the EU Habitats Directive. It also occurs on thin spoil in crevices and on ledges of old walls in and near disused mine sites. Its occurrence away from metal-rich ground, in the past at least, suggests it is a facultative metallophyte, able to tolerate copper and tin, but its principal requirement is zero competition.

A member of the Suboceanic Boreal–montane element, it shows a European–western N American disjunction. It is mainly a N European species but extends S to northern Spain, and to Russia in the east. In the BI it occurs in Ireland (three post-2000 localities) and southern England. It was recorded frequently by W.E. Nicholson (1866–1945) in Sussex in the early 20th century (earliest known record 1906) and by E. W. Jones (1909–1992) in Berkshire in 1939 and 1946, but there are no recent records from these counties. It was possibly lost as a result of the lack of grazing on lowland heaths. It now survives only on old mine spoil at 7 localities in E Cornwall and 13 localities in W Cornwall, overall in eight 10km squares since 1980. It was not recorded in Cornwall until the early 1960s, by J. A. Paton, perhaps because it was overlooked by earlier bryologists or, more likely, the apparent monotony of old mine spoil did not invite close inspection.



Cephaloziella integerrima

Recent survey by D. T. Holyoak under the UK BAP has revealed its presence at several abandoned mine sites but it remains a Nationally Rare plant. It is known to occur on four SSSIs: Phoenix United Mine SSSI, Crow's Nest SSSI (combined as Phoenix United Mine and Crow's Nest SAC), West Cornwall Bryophytes SSSI, which supports a significant part of the English population, and Penhale Dunes SSSI. Nevertheless many populations have no protection. The plant soon disappears if open ground is colonized by other non-specialist bryophytes or grasses and other vegetation, a process that inevitably occurs as the metal-rich soils are weathered and the toxicity to other plants is ameliorated. Neglect of old mine sites is thus a threat to this tiny liverwort. Disturbance of the spoil is required to provide fresh substrate; this can occur naturally, for example by scouring by water or scarification. Alternatively, large-scale earth moving may have to be done as part of a management strategy for this and other metalliferous bryophytes. Other threats include the loss of old mine sites to development or some other land use changes, such as afforestation. All too often such areas are regarded as eyesores and are targets for misguided tidying-up schemes.

Cephaloziella integerrima has shown a decline in both extent and area occupied, and as its habitat continues to be lost or deteriorates in quality, this species is therefore cited as Vulnerable on the revised British Red List.

*Cephaloziella massalongi***Lesser Copperwort**

VU

NR

No change

This species, named after the Italian bryologist C. Massalongo (1852–1928), is a tiny leafy liverwort forming a smooth mat or solitary creeping shoots, very similar to the closely related *C. nicholsonii* (page 75) in having toothed leaf lobes, but generally even smaller in all its parts. Individual shoots are up to 7 mm long and less than 0.5 mm wide, but under optimal conditions can form dense patches. Microscopic examination is necessary for reliable identification, particularly of plants growing in that which can be hard to name. It is very rarely fertile in Britain, and is presumed to be dioicous (a character shared only by *C. dentata* (page 70) and *C. divaricata* in Britain) and sporophytes are unknown in Britain. Specialized asexual propagules in the form of ovoid-ellipsoid gemmae on the margins of the upper leaves are common and normally abundant. It behaves as a colonist.

It is restricted to copper-bearing rocks, and sandy to clay lithosols derived from them, typically on rocky mine spoil or silt, on wet or moist rocks, often but not exclusively on north-facing slopes. It is intolerant of dense shade but is often found on bare ground amongst gorse bushes and under a sparse tree canopy. It is infrequently found in drier situations amongst low heather and sparse grasses within a vegetation type known as Calaminarian grassland, a habitat listed on Annex I of the EU Habitats Directive. It can form dense extensive mats on banks alongside streams that drain copper-rich ground and also occurs in crevices of old mine buildings and walls. It is often found with or near *C. nicholsonii* and other leafy liverworts.

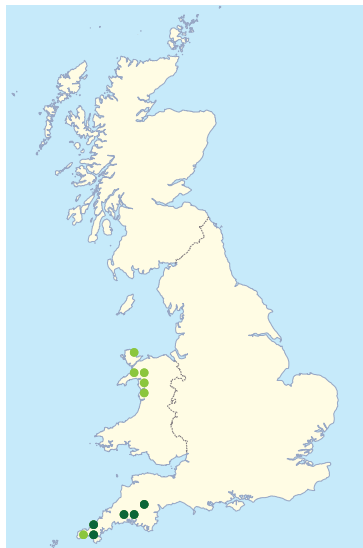
A member of the Suboceanic Boreo-temperate element, it shows a rather disjunct distribution. It is widespread but scattered throughout much of Europe and is listed as rare (ECCB, 1995). Elsewhere it is known from N America, Japan and Nepal and is considered to be globally rare. In the BI it is known from Ireland, Wales and England. Cornwall is its stronghold, where since 1992 it has been recorded from about 15 tetrads (2 × 2 km squares) in the W of the county, and six tetrads in the E. Amongst the earliest English records are those from Penzance and Carbis Bay, collected by W. Curnow (1809–1887) and G. E. Davies in 1886 (there is an earlier unconfirmed record from Carbis Bay dated 1884). It was last seen in the Carbis Bay area in the early 1960s. However, D. T. Holyoak added several new records to Cornwall during 2003–2005 and found it new to N Devon in 2009, on damp mine spoil at South Zeal. The species is currently listed as Nationally Rare but recent survey has shown it to occur in at least 20 10 km squares post-1980, placing it in the Nationally Scarce category. Although some populations have undoubtedly been lost in Cornwall, the discovery of new populations suggests that any decline in England has been minimal.

The demise of the Cornish mining industry has implications for *C. massalongi* and other metallophytes and losses of some populations would seem inevitable; new ground for colonization is no longer being created. It is not on the UK BAP list and is therefore not covered by Section 41 of the NERC Act 2006 that would oblige Local Planning Authorities (LPAs) to take account of it when decisions are being taken that would impact upon biodiversity. Large expanses of former mining areas are classed as derelict land and are being lost to development, landscaping, general ‘tidying-up’ and restoration of old mine buildings, but the greatest threat is scrub encroachment due to neglect. The metal-rich soils gradually lose their toxicity through weathering, and other vegetation such as grasses, herbs



Restricted to copper-rich substrates, *Cephaloziella massalongi* forms gemmae at the shoot tips.

Photo: Des Callaghan.



Cephaloziella massalongi

and woody plants invade eventually ousting this species and other metallophytes. Four SSSIs in Cornwall support populations of this liverwort: Godrevy Head to St Agnes SSSI, West Cornwall Bryophytes SSSI (which supports about 20% of the known British population), Phoenix United Mine SSSI and Crow's Nest SSSI, the last two combined as the Phoenix United Mine and Crow's Nest SAC. The Devon sites are unprotected.

Consideration should be given to providing fresh metal-rich substrate, either by exposing fresh sub-soil or moving large amounts of fine-grained toxic soils to suitable receptor sites, and undertaking translocation if natural colonization fails. A technique providing a convenient and rapid way of determining the concentration of copper and other elements in sub-soils and spoil at donor and/or recipient sites using a soil auger and hand-held x-ray fluorescence spectrometer has been described by Callaghan & Bowyer (2011) and may prove useful in such habitat recreation schemes. The classification of *C. massalongi* as Vulnerable on the revised British Red List is an implicit acknowledgement of a decline in habitat quality and extent.

L

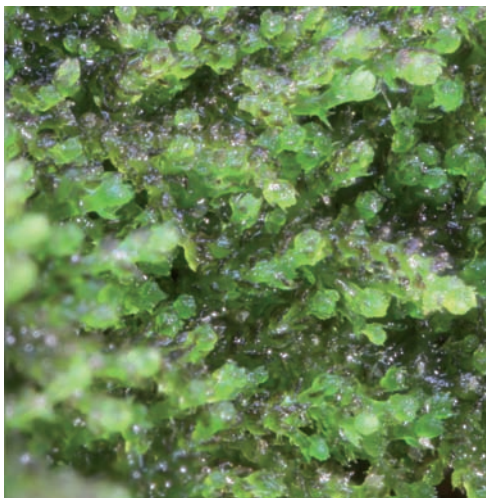
JUNGERMANNIALES

Cephaloziella nicholsonii

Greater Copperwort

VU	BAP; NS
No change	

This species, named in honour of the eminent Sussex bryologist W.E. Nicholson (1866–1945), forms smooth mats or scattered creeping shoots about 10 mm long and 0.5 mm wide. The colour varies, typically greenish but sometimes with purplish-red tints. The combination of toothed leaves, smooth asymmetrical gemmae on the upper leaf margins, and the habitat,



A pure mat of *Cephaloziella nicholsonii*, its world headquarters in Cornwall. Photo: Des Callaghan.



Cephaloziella nicholsonii

may point to this species. It often grows with the Red Listed *C. massalongi* (page 74) and whilst well-grown *C. nicholsonii* is normally larger than the former (apparent in mixed populations), microscopic confirmation is required. It is monoicous but sporophytes are unknown. It behaves as a colonist.

It is restricted to copper-bearing rocks and sandy or clay soils derived from them in the vicinity of disused copper mines, from sea-level to 275 m. Recent analysis of soil at one site (Penberthy Croft Mine) showed high levels of arsenic, copper and lead. It prefers bare open ground, often amongst low heather and sparse grasses within a vegetation type known as Calaminarian grassland, a habitat listed on Annex I of the EU Habitats Directive. It may form dense mats alongside streams and ditches yet it can also tolerate dry sites. It frequently grows on dry stone walls and on old mine buildings. It is occasionally associated with the Red Listed moss *Scopelophila cataractae* (page 157).

This Oceanic Temperate species is more or less restricted to the BI, known from Ireland, Wales and England. There is an old record (1936) from Germany and a doubtful record from Spain. The earliest English record is 1907, collected by W.E. Nicholson from copper-rich rocks at Carbis Bay in W Cornwall (where it still occurs). However, bryologists of the day expressed doubts regarding its distinction from *C. massalongi* and it was omitted from later checklists. Eventually J.A. Paton showed that the two species are distinct and thus she reinstated *C. nicholsonii* on the British list (Paton, 1984). The English (and indeed world) stronghold of this liverwort is in Cornwall with the species having been recorded at just over 40 localities since 1950. Recent fieldwork by D.T. Holyoak for the UK BAP has shown that it occurs in about 23 localities in W Cornwall and 7 in E Cornwall (Holyoak, 2005). The main populations are within SSSIs, including West Cornwall Bryophytes SSSI that supports several sub-populations, Aire Point to Carrick Du SSSI, Penberthy Croft Mine SSSI, Cabilla Manor Wood SSSI, Crow's Nest, and Phoenix United Mine SSSI (Phoenix United Mine and Crow's Nest SAC) which supports the largest known population. *C. nicholsonii* has been recorded from at least

six localities in Devon, but, post-2000, only from Brook Wood in S Devon, discovered in 2009. It is not known to occur on any SSSI in Devon. The only other occurrence in England is an outlier in Cheshire, within Alderley Edge SSSI, found in 1997 on sandy ground of a disused copper mine.

Since 1950 this species has been recorded from 19 10km squares and is classified as Nationally Scarce, yet there have been losses. With the collapse of the Cornish mining industry suitable ground for this plant and other metallophytes is no longer being created. It may be possible, however, to re-create suitable metal-rich ground, as explained under *C. massalongi*, and the threats faced by that plant are equally relevant here. Even SSSIs are not sacrosanct; in 2003 a company was found guilty of damaging an SSSI that led to the partial loss of *C. nicholsonii*. The court ordered that restoration be carried out and, whilst this may mitigate some of the damage, it represents yet another bite from a diminishing resource.

The most insidious threats are the gradual leaching out of the heavy metals and scrub encroachment due to neglect; it can survive for a number of years in light or moderate shade (unlike some other metallophytes) but eventually disappears; many populations have thus succumbed. Sites should be visited every two or three years with a focus on the known *C. nicholsonii* areas. Consideration should also be given to the inclusion of the liverwort in the *ex situ* threatened bryophyte facility at RBGK. It is listed as Vulnerable on the revised British Red List, an implicit reflection of a decline in the quality and extent of its habitat.

M

DICRANALES

Ceratodon conicus

Scarce Redshank

CR

BAP; NR

Upgraded

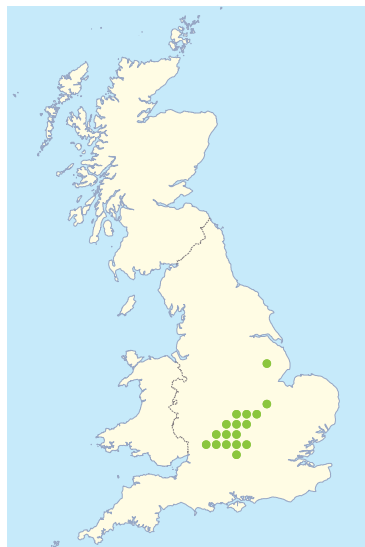
This species, barely 10mm tall, forms yellowish-green turfs or inconspicuous scattered shoots. It has tiny triangular tapering leaves with entire margins and a nerve that extends beyond the leaf tip. It is dioicous and sporophytes are rare. There is no swelling (struma) at the junction of the erect capsule and seta (unlike *C. purpureus*, which does have a struma). Its separation from *C. purpureus* is difficult; mature capsules are necessary so that the peristome can be examined microscopically. Specialized asexual structures are unknown and it shows a colonist life-history strategy.

A strict calcicole, it grows on dry bare sandy or clayey soils overlying Oolitic limestone, in stone quarries, along track-sides and in cracks between paving stones, in churchyards and on garden paths and walls. It has also been recorded from the coping stones of a canal. In the 19th century it was known on the tops of earth-capped limestone walls, a habitat that has vanished. It was on such sun-baked, soil-capped walls that a number of other notable bryophytes occurred (Porley & Hodgetts, 2005), including *Pterygoneurum lamellatum* (see page 204).

A member of the Submediterranean–Subatlantic element, it is known from Norway, Sweden, Germany, the Alps and Crete. Elsewhere it is known from the Canaries, N Africa and SW Asia. In the BI *C. conicus* is restricted to England with a distribution centred on Northamptonshire and Oxfordshire. The earliest record was made in 1884, at Duston, Northamptonshire, by the great Victorian bryologist H.N. Dixon (1861–1944) who made several more collections in the county up to 1897 (Dixon was not entirely convinced that the species was distinct from *C. purpureus* having observed numerous intermediates and



The colony of putative *Ceratodon conicus* (centre) on the edge of Bristol in West Gloucestershire, pending DNA results. Photo: Richard Lansdown.



Ceratodon conicus

thought at best it should be ranked as a subspecies of *C. purpureus*). It was last seen in the county in 1918, by P.G.M. Rhodes (1885–1934). The last confirmed record in England was in 1990, in Oxfordshire, in the garden of one of Britain’s most eminent 20th century bryologists Eustace W. Jones (1909–92). EWJ probably knew this species better than any of his contemporaries and recorded it many times in the county but only once found the remnants of capsules, in 1949 at Cuddesdon, Oxfordshire (Jones, 1991). In 1990, EWJ (in litt.) remarked that *C. conicus* grows in the “*kind of places where no sane bryologist would look for anything unusual, so there may be plenty of it around, but on the whole I think not*”. He had no doubt, though, that *C. conicus* was a good species, a conclusion subsequently reached by Burley & Pritchard (1990) in their taxonomic study. It even grew on EWJ’s garden wall and bryologists would be taken to admire it. However, the 1975/6 hot summers, combined with birds pecking at the bryophyte mat and a dearth of suitable earth capping, took its toll. A lorry that partly demolished the wall was the last straw, and the moss vanished in 1977. But in 1989, EWJ discovered a small quantity hiding in cracks of the garden path and transplanted a few shoots to a pot; in 1990 it was said to be “*growing nicely*”. Two years later EWJ died and the fate of the potted *C. conicus* remains unknown.

Repeated searches have failed to re-find the plant at some of its most recent confirmed sites. However, in 2011 P. Martin discovered a very likely candidate at a Local Nature Reserve at Shirehampton on the edge of Bristol. It occurred on thin soil overlying concrete associated with a range of other calcicole bryophytes; ‘ordinary’ *C. purpureus* was close by and looking very different. Although sporophytes were not present, vegetative material was collected for DNA barcoding under a defra-funded project at RBGE. The analysis requires recently collected material; herbarium material over ten years old is normally not suitable. The results are eagerly awaited.

There is no published Action Plan for this species but there are initiatives underway. One pioneering project, under the auspices of the Cleve Common Board of Conservators and a

landowner, supervised by R. Lansdown, aims to recreate the traditional mud-capped Oolitic stone walls on Cleeve Common and on a farm in the Cotswolds. Even if the species does not return by ‘natural means’, it opens up the possibility of a translocation (particularly if the Bristol plant turns out to be *C. conicus*). Given the rapid decline in habitat quality, and the very restricted range with very few individuals, *C. conicus* has been upgraded from Endangered (Church *et al.*, 2001) to Critically Endangered on the revised British Red List.

M

DICRANALES

Cheilothela chloropus

Rabbit Moss

VU	NR
New addition	

Cheilothela, meaning ‘thick nipple’, a reference to the thickened beak on the capsule lid, is a dull yellowish to brownish-green turf-forming acrocarp up to 10 mm tall. The leaves have plane margins and taper from a narrow base to a sharp apex giving the shoots a spiky appearance when moist, and held close to the stem when dry; they are more than one cell thick which gives them an opaqueness and rigidity. The dullish appearance is due to numerous rounded protuberances (mammillae) on both upper and lower surfaces. It is dioicous and sporophytes are unknown in Britain and are rare throughout its range. There is likely a relationship between its rarity in England and its failure to produce sporophytes, possibly due to suboptimal conditions operating at the edge of its range (Longton, 1992). Specialized asexual propagules are unknown, although it has a network of subterranean axes that may aid local dispersal and maintenance (Porley, 1992) via clonal reproduction. It behaves as a colonist.



A mat of *Cheilothela chloropus* showing the characteristic bristly shoots. Photo: Ron Porley.

It is predominantly a coastal moss of short rabbit-grazed (hence the English name) herb-rich calcareous turf, or on thin soils amongst rock outcrops on south-facing limestone hills and sea-cliffs, more rarely on dune slacks, from sea level to about 80 m. It does not tolerate shading but is often associated with a sparse growth of grasses and herbs. It is often associated with several notable lichens and a diverse range of bryophytes including *Didymodon fallax*, *Pleurochaete squarrosa*, *Scleropodium touretii*, *Trichostomum brachydontium* and *T. crispulum*.

A member of the Mediterranean–Atlantic element, it is frequent in Mediterranean countries and along the Atlantic seaboard, extending east to Bulgaria, Albania and Turkey. Elsewhere it is known from Macaronesia, N Africa and is reported from S Africa. In the BI it is known only from England, where it has been recorded from two vice-counties, S Devon and N Somerset. It was first discovered in England by the Revd. C. H. Binstead (1862–1941) in 1929 on a rocky limestone slope near Clevedon, where it persists to this day.



Cheilothela chloropus

Most of its occurrences are on the Devonian limestone around Torquay, including Hope's Nose, Berry Head (the population covers about 10 m²), Wall's Hill (where turfs can be up to 35 cm across) and Daddyhole Plain, and in N Somerset it occurs on Carboniferous limestone at Walton Common near Clevedon and at Sand Point (good populations can be found along the main, well-trodden path), where it was first found in 1961 by J. Appleyard (1906–1989). In 2003, it was found by D. T. Holyoak on damp sand near the edge of a dune slack at Dawlish Warren, S Devon, occupying an area of several square metres, with the largest pure patch some 27 × 12 cm. This is the first record away from the limestone hills. Most of the English population falls within six SSSIs (Berry Head to Sharkhan Point SSSI/SAC, Daddyhole SSSI, Dawlish Warren SSSI/SAC, Hope's Nose to Walls Hill SSSI in S Devon and Middle Hope SSSI and Walton Common SSSI in N Somerset). Only one locality is not notified, Petit Tor Point, which lies adjacent to Babbacombe Cliffs SSSI.

The principal threat is scrub encroachment and shading. Many of the populations are at risk if grazing pressure is relaxed, and there is some evidence that this is happening, particularly with respect to a decrease in rabbit numbers. At Walton Common SSSI, the *locus classicus*, a 30 × 10 m monitoring scheme was established in 1991 employing random nested quadrats. The data indicate that *C. chloropus* is declining and the niche is being diminished by an increase in tall herbs, grasses and woody plants such as brambles and young Ash. It is imperative to open up the area and also crucial that monitoring continues. Recently, cattle have returned to Walton Common but they rarely graze the rocky bank where the moss occurs. Rabbit grazing has also apparently decreased.

Since 1990 four new localities have been discovered and it is a species that may benefit from climate change if southern England experiences an increasingly Mediterranean-like climate in the future (Porley & Hodgetts, 2005). It is not on the UK BAP list. Most populations

occur on SSSIs but regular surveillance is required with attention to grazing levels. Because *C. chloropus* is not a notified feature on the SSSI documentation, and has only very recently been regarded as a qualifying species, there is a danger that it will be overlooked during site condition assessments. In recognition of its restricted range and very few populations, it has been added to the British Red List for the first time, listed as Vulnerable.

M

POTTIALES

Cinclidotus riparius

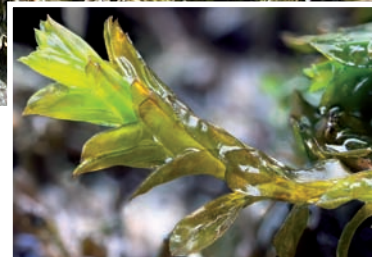
Fountain Lattice-moss

VU

NR

No change

Cinclidotus, from the Greek 'lattice-like', referring to the peristome around the capsule mouth, is a dark green to blackish compact aquatic plant attached to the substrate, with shoots to 5 cm long. Leaves have thickened margins and a strong nerve extending to the rather blunt apex, are slightly twisted when dry and spreading when moist. It is very similar to, and often grows with *C. fontinaloides*, but that species is typically more straggling with narrower, more sharply pointed leaves; microscopic examination of transverse sections of leaves is, however, necessary for certain identification. The species is dioicous, only female plants are known in the BI and sporophytes are unknown. In Europe it is apparently a colonist (Dierßen, 2001), but in Britain the low reproductive effort exemplifies the perennial stayer strategy.



Cinclidotus riparius typically occupies a zone at normal water level on rocks by lowland rivers.

Photo: Michael Lüth (Germany). **INSET:** A close-up of *Cinclidotus riparius* showing the thick leaf border with a strong nerve ending in a blunt leaf tip.

Photo: Des Callaghan.

It flourishes in flowing water (hence the epithet *riparius*), attached to rocks and stones on natural outcrops and on walls, in open situations or under light shade of riverside Alder. It occupies a zone more or less at normal water level and is therefore submerged during winter flows and exposed during the summer. The *C. riparius* zone is typically lower than that occupied by *C. fontinaloides* although there is some overlap.

A member of the Eurosiberian Temperate element, it has a mainly southern distribution in Europe being widespread in the countries bordering the Mediterranean, and extending north to The Netherlands, Germany and Poland. Elsewhere it is known from Turkey, the western Himalaya (Kashmir), Afghanistan and N Africa (Morocco). In the BI the earliest record dates back to 1884 from Clare, Ireland (not found since). The first English record, in 1890, is attributed to A.W.Weyman (1860–1935), a Ludlow solicitor. He collected it from the River Teme at Ludlow, Shropshire, where it can be found to this day in some abundance at, for example, Ludford Bridge.



Cinclidotus riparius

The question of whether *C. riparius* occurs in the BI has been a matter of dispute for more than 100 years (Blockeel, 1998). The early records were initially accepted as this species by the experts of the day (R. Braithwaite (1824–1917), W.P. Hamilton (1840–1910) and H. Boswell (1834/5–1897) amongst others), but the Victorian bryologist H.N. Dixon (1861–1944) cast doubt on the identity of the collections. In the 3rd edition of the *Student's Handbook of British Mosses* (Dixon, 1954) he stated

“Cinclidotus riparius, which has been included in our Moss-flora, must be expunged. All the specimens so named proved to be forms of C. fontinaloides with shorter, broader leaves than usual”.

Although W. E. Nicholson (1866–1945) initially concurred with this view he changed his mind when, in 1931, he saw the plant in the River Teme for himself. As a consequence it was, for a while, reprieved and placed on the British and Irish list, only for doubts yet again to surface, this time floated by E. F. Warburg (1908–1966) who believed the issue could not be resolved in the absence of sporophytes. Thus, in the 3rd edition of the *Census Catalogue of British Mosses* (Warburg, 1963) it is flagged up as doubtful and this was enough to once again effectively erase *C. riparius* from the consciousness of British field bryologists.

That is until 1988 when T. L. Blockeel, after seeing fertile material during a visit to Greece, noticed that there was a difference in the leaf border in *C. riparius* and *C. fontinaloides* as seen in transverse section under the microscope. In 1996, TLB led a BBS workshop to consider the value of transverse leaf sections in moss taxonomy and the opportunity was taken to examine herbarium material of *Cinclidotus* from Britain and abroad. It was evident that British material of *C. riparius* matched continental material in detail of the transverse section of the leaf border; moreover the leaf border of *C. fontinaloides* in transverse section was quite different, providing a reliable means to split the two plants on vegetative characters alone (Blockeel, 1998). As a result, *C. riparius* was reinstated on the British list.

The current distribution covers a total of four hectads along the River Teme but its confinement to this river is curious. The Teme, the second largest tributary of the River Severn is a river type associated with sandstone and mudstones that is especially characteristic of the Welsh Marches, but not restricted to them. There is no specific conservation action directed at this species and it is not on the UK BAP. Its known localities are afforded some protection within the River Teme SSSI although it may be vulnerable to any changes resulting from pollution or unsympathetic riverbank management. It is classified as Vulnerable on the revised British Red List on account of its restricted range.

M

HOOKERIALES

Cyclodictyon laetevirens

Bright Green Cave-moss

EN

BAP; WCA; NR

No change

This moss, the only European member of a largely tropical genus, is a bright green (hence '*laetevirens*') creeping pleurocarp forming rough mats with regularly branched shoots to 8 cm long, often much less. The oval leaves have visibly large cells, a double nerve and a border of long narrow cells running into a short sharp point; they are arranged in one plane giving a flattened appearance to the shoot. It is monoicous and sporophytes are uncommon. Asexual propagules are absent and it behaves as a perennial stayer.

In England, the plant grows in the half-light of a humid sea cave, on more or less moderately infertile vertical rock walls where mildly basic fresh water percolates through the rock from the ground above keeping the mat constantly moist. It is adapted to low light levels and requires high humidity. It is associated with the thalloid liverwort *Conocephalum conicum*.



LEFT: A moist, glistening shoot of *Cyclodictyon laetevirens* in a Cornish sea cave. RIGHT: A leaf of *Cyclodictyon laetevirens* as seen under the microscope showing the long double nerve, distinct border and relatively large cells. Photos: Sean Edwards.

A member of the Hyperoceanic Southern-temperate element, it is restricted to the oceanic fringe of Europe, including Portugal and Spain (where it is considered Vulnerable), and the Azores and Madeira, and is listed as rare in Europe (ECCB, 1995). Elsewhere it is known from tropical Africa including Madagascar and S to the Cape of Good Hope. In the BI it is known from several localities in Ireland (mostly in the SW), on the Isle of Jura in Scotland and from a single locality in W Cornwall, England. The first English record, collected in 1840 by the botanist and surgeon J. Ralfs (1807–1890), was from a sea cave near Penzance, where it continues to survive to this day.



Cyclodictyon laetevirens

The tale of this moss in England is legendary. It concerns a close friend of Ralfs, W. Borrer (1781–1862), a botanist from Sussex. During a ramble along the Cornish coast Borrer alighted upon the beautiful moss *Hookeria* [*Cyclodictyon*] *laetevirens*, but not until he had returned home did he realize that it was new to England. Borrer asked a local cleric friend to collect some so he could distribute material to fellow bryologists as was the custom in the early days of bryological endeavour. In order that no one else other than Borrer should discover this ‘prize’, the vicar in his misguided enthusiasm proceeded to strip the entire population of *C. laetevirens* from the cave. Borrer was alarmed by this and in the process of informing a fellow bryologist discovered that Ralfs had collected the same species some months earlier in what transpired to be a different Cornish cave. Thus, following their fateful contact, not only did a life-long friendship develop between Ralfs and Borrer but the moss survived in Ralfs’ cave (Marquand, 1890). This was not quite the end of the story; following a succession of visits (and collecting) by eminent bryologists during the early 20th century, W. E. Nicholson (1866–1945) was the last to document the moss, reporting it in his 1933 diary as scarce and overgrown with *Conocephalum concium*. Subsequent searches of caves near Penzance were unsuccessful (Paton, 1969) and amidst claims of over-collecting and rumours that the cave roof had collapsed came the bleak pronouncement that *C. laetevirens* was extinct in England (Birks, 1994). The best anecdotes have a happy ending, and so it was in 1996, when *C. laetevirens* was re-found flourishing in Ralfs’ original cave. A follow-up visit in 1998 estimated the population to be covering an area of rock wall about 30 × 70 cm, dripping with moisture, and with *Conocephalum conicum*. A few shoots were present on the floor at the base of the wall, presumably sloughed off, possibly from the weight of water that was saturating the mat. Information retrieved in 2012 from a data-logger placed by the colony showed that the temperature inside the cave is buffered from fluctuations outside and probably never falls to sub-zero.

This moss remains at risk in its sole English sea cave from illegal (and indeed immoral) collecting: it is fully protected under the WCA 1981. Cornish material is held in sterile culture in the *ex situ* threatened bryophyte facility at RBGK, but otherwise there is no specific conservation action. Groundwater, which trickles into the cave from the surrounding agricultural land, may pose a risk, and a buffer zone in the catchment area to reduce nutrient

run-off would seem to be a prudent measure. A potential risk is posed by climate change; rising sea levels may one day inundate the sea cave (Bates & Preston, 2011). The site receives no statutory protection but is within an AONB. It is classified as Endangered on the revised British Red List on account of the very small population.

M

DICRANALES

Cynodontium polycarpon

Many-fruited Dog-tooth

VU

NR

Upgraded

This is a green cushion-forming moss of variable size, but usually no more than 4 cm tall. *Cynodontium* (from the Greek) refers to the supposed resemblance in the closely related *C. bruntonii* of the peristome to a dog's tooth (ironically this species has now been transferred to another genus, *Oreoweisia*). The long, narrow gradually tapering leaves are contorted when dry and when moist become erect to spreading; they have recurved margins to above half-way and are toothed at the apex. It is monoicous and the capsules, which are freely produced, are straight with longitudinal furrows. Specialized asexual propagules are unknown and it behaves as a colonist.

It is a mountain plant, growing in crevices on vertical siliceous rock faces, typically where it is cool and shaded, or on sheltered screes. Associated bryophytes include *Andreaea rupestris* and *Diplophyllum albicans*.



LEFT: *Cynodontium polycarpon* in its typical rock crevice niche. RIGHT: A close-up of *Cynodontium polycarpon* capsules showing the membranous calyptra or hood.

Photos: Štěpán Koval (Czech Republic).



A cushion of *Cynodontium polycarpon* with capsules at various stages of development.

Photo: Tomas Hallingbäck (Sweden).



Cynodontium polycarpon

A member of the European Boreal–montane element, *C. polycarpon* is discontinuously circumboreal and widespread throughout most of montane Europe; it is most frequent in parts of Scandinavia and extends south to Spain and Portugal (where it is thought to be extinct). Elsewhere, it is known from the Caucasus, C Asia, Japan, Canada and Greenland. In the BI it is known from Scotland, Wales (last record 1970) and England. It has been reliably confirmed from two English vice-counties: Cumberland and N Northumberland. There is a recent (1998) record from Braemar, Scotland, discovered by G. P. Rothero but it has not been seen in England for nearly 50 years

The earliest confirmed English record is dated 1959, collected once by Welsh-born bryologist R. D. Fitzgerald (1914–1990) at Buttermere Fells in Cumbria. Older records of this species are unreliable and it was not until A. C. Crundwell (1923–2000) brought some order to the genus in 1960 that British bryologists began to understand the group; only plants with ripe capsules can be named confidently. The next and last specimen collected in England in 1963 was by J. Appleyard (1906–1989) from a burn in the Cheviot Hills, N Northumberland. Both were amateur bryologists in the true sense of the word and both had an exceptionally good ‘eye’ in the field. No one else has seen *C. polycarpon* in England again.

As a result of its rarity in Britain, little is known of the ecology, reasons for its decline or potential threats. Fundamentally *C. polycarpon* is a mountain plant of the boreal forest zone, and England is therefore probably marginal in terms of its ecological and climatic space. Belonging to the European Boreal–montane element, climate change may already have negatively impacted on its more southerly populations. It is not on the UK BAP and there is no specific conservation action or programme devoted to it. It was listed as Data Deficient in the *Red Data Book* (Church *et al.*, 2001) but in the revised British Red List it has been upgraded to Vulnerable in recognition of its very restricted range.

*Diallytrichia saxicola***Brittle Lattice-moss**

VU

NR

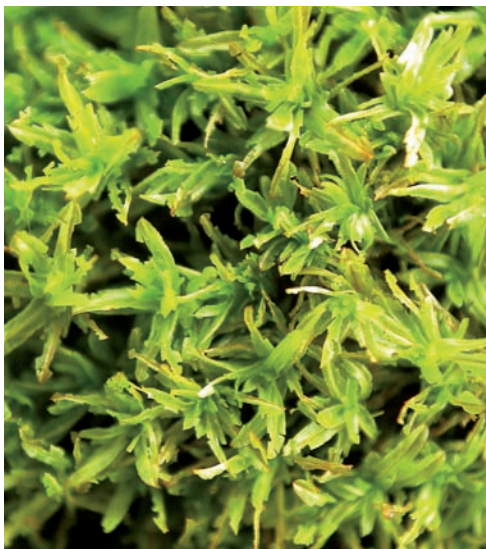
Formerly not evaluated

Formerly known as *Diallytrichia fragilifolia*, this moss forms small, light to dark green (sometimes grey from silt), compact tufts or loose cushions up to about 10 mm tall. The strongly nerved leaves are parallel sided with a rounded apex that terminates in a small point and the upper leaf margins are crenulated (scalloped). When dry the leaves are loosely twisted around the stem but spread when moist. The fragile nature of the leaves provides a good field character; sometimes only the nerve remains after the leaf lamina has broken away giving a bristly appearance to the cushions. Confusion with fragile leaved forms of the very similar *D. mucronata* is possible: the upper leaf margins of this plant tend to be smooth with no scalloping. Microscopic examination of plants is nevertheless advised. The species is dioicous but gametangia (sex organs) have not been seen in Britain. The cast-off leaf fragments are thought to act as asexual propagules and it behaves as a colonist.

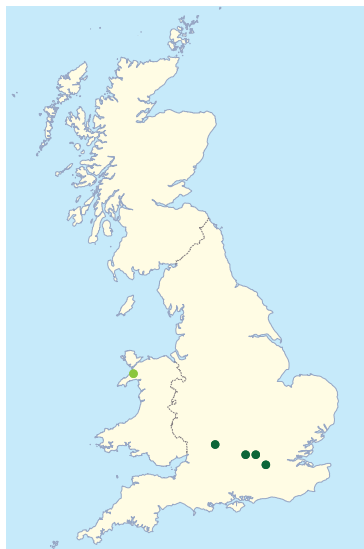
The largest colonies occur on concrete edifices such as defence structures along the river Thames. It also grows within the flood zone on a shaded concrete bridge support of a tributary emptying into the Thames, and on trees, both on healthy individuals and on standing dead trees or on detached bark lying on the ground, often some distance from water.

This European endemic shows an Atlantic distribution, but its full range has yet to be established. The taxonomy of *Diallytrichia* has only recently been resolved including the relationship between *D. saxicola* and *D. mucronata*. Currently *D. saxicola* is known from Portugal, Spain, France and SW Germany but it may be found elsewhere. The identity of *D. saxicola* as a British plant was not elucidated until 2007 (Bates, Matcham & Lara, 2007); subsequent study of herbarium material has shown that it occurs in England, centred on the Thames, and there is an old Welsh record (1927).

The earliest known English record, from the trunks of Beech trees, was made by J. W. Bates in 1987 close to the River Thames near Marlow, Berkshire, but named as *D. mucronata*. In 2005, the site was visited by the Southern Group of the BBS; the plant was still present but the October 1987 storm had ravaged the woodland with the loss of some Beech trees. Discussion ensued over the curious fragile nature of the leaves and after further investigation it transpired that the plant was indeed the species now known as *D. saxicola*. An earlier collection made by JWB from a concrete bridge by the confluence of Bow Brook and the River Thames near Cholsey in 1988 also turned out to be this species; a small population is still present here. Notice of the plant in Britain, combined with a better understanding of its relationship with *D. mucronata*, was expected to reveal further localities. In 2009, it was found on the Oxfordshire side of the Thames, at Wallingford, and in 2010 R. Lansdown and N. Monaco found an extensive population on concrete flood defences along the Thames from Datchet through Staines to Laleham, on both the Surrey and the Middlesex sides of the river. One particular colony, immediately W of the M25 motorway at Hythe End, occupied an area of some 10 m² and approached 60% cover on concrete. An occurrence on an ornamental maple was discovered by P. Martin in 2010 in the Abbey Gardens, Cirencester in E Gloucestershire, and in 2011 it was reported for the first time in Buckinghamshire by S. V. O'Leary on concrete along the Thames towpath near Marlow (the last two records are not shown on the distribution map).



Diallytrichia saxicola, showing the characteristic fragile, fragmented leaves. Photo: Ron Porley.



Diallytrichia saxicola

Potential threats to this recent addition to the British flora have yet to be evaluated. None of the known sites are protected (the Marlow population falls just outside Bisham Woods SSSI). This species was not evaluated in the British RDB (Church *et al.*, 2001), but in the revised British Red List it is classified as Vulnerable due to its current restriction to a few locations.

M

DICRANALES

Dicranum spurium

Rusty Fork-moss

VU

BAP; NS

No change

This acrocarpous moss varies in size, forming golden-green tufts 5 cm or more tall, sometimes less, or scattered shoots. It has relatively broad leaves that taper to a fine tip, which when dry are crisped and wavy and the upper leaves are tufted. When moist the leaves point away from the stem, and superficially resembles some forms of the common *D. scoparium*. The moss is dioicous and sporophytes are very rare. Fragile shoot tips are thought to aid local dispersal and it is a perennial stayer, investing little effort into sexual reproduction.

A plant of lowland heathland, it is particularly characteristic of the zone between wet and dry heath, often on sloping ground. It is associated with *D. scoparium*, *Hypnum imponens*, *H. jutlandicum*, *Pleurozium schreberi*, *Polytrichum commune* and *Sphagnum compactum*.

A member of the European Boreal–montane element, it occurs throughout N, W and C Europe but is rare in the S where it often occurs in pine forests. Elsewhere it is known from Siberia, Himalaya and eastern N America. In the BI it occurs in Scotland (under scattered Scots Pine on steep river terraces or in upland heath) and England. Dickson (1973) has speculated that it may have shown a more continuous distribution in the early Flandrian,



LEFT: A tuft of the lowland heathland moss *Dicranum spurium* at Woolmer Forest, Hampshire. Photo: Fred Rumsey. RIGHT: A close-up of a tufted shoot of *Dicranum spurium* showing the crisped leaves. Photo: Des Callaghan (Scotland).

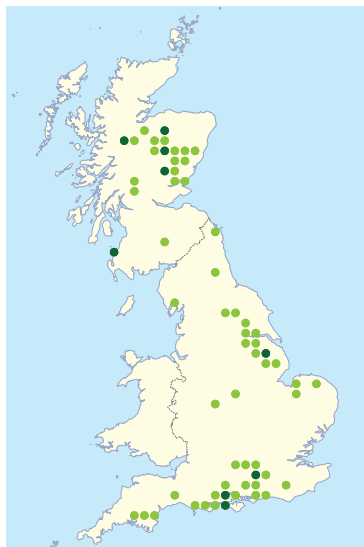
the present interglacial period, about 12,000 years ago. Known in England since at least the mid-1800s, it was recorded from various moors and heaths in Yorkshire by R. Spruce (1817–1893), W. Wilson (1799–1871) and J. Nowell (1802–1867). However, it seems it was not known in southern England until the end of the 19th century, originally in Surrey by G. L. Lyon in 1899 and at Tilford Common by L. J. Cocks (1859–1921/2) in 1913. It is a species that has undergone a marked decline and although classified as Nationally Scarce it has disappeared from many of its former sites. This decline has been much more precipitous in England than in Scotland. A similar decline has also been reported from The Netherlands (Grevén, 1992).

Factors responsible for its decline include neglect of heathland, with an accumulation of litter and the invasion of woody species, burning, overgrazing, nitrogen deposition, drainage and afforestation. Ammonia pollution in particular has been implicated (Dierßen, 2001). Emissions of ammonia between 1990 and 2000 declined by about 5%, but they are still much higher than they were 50 years ago. Up to the 1970s there was no suggestion of a decline in this species, but the frequency of records thereafter tailed off with few records in the 1990s and 2000s, a scenario that is consistent with the escalating level of ammonia emissions.

There have been no records from the S Yorkshire heathland since 1970, largely as a result of drainage and afforestation. The last record from Sandringham Warren, Norfolk was in 1967, and a recent survey of Linwood Common SSSI in Lincolnshire, where *D. spurium* was known for about 20 years, concluded that it has vanished (Hodgetts, 2007). In Berkshire it has probably been lost (Bates, 1995), and a recent survey of historical and potential sites in Surrey, undertaken by the local recorder H. Wallis over six years, also failed to re-find the plant. It is still present (2009) just over the border in N Hampshire, at Minley in Fleet Pond SSSI, where first recorded in 2002, and at Woolmer Forest SSSI (seen in 2012). The current stronghold in England would appear to be the New Forest – it may be no coincidence that

burning is practised much less here. Since 2000 it has been seen in seven or eight places in the Forest, including Cadnam Common, Wilverley Bog, Matley Heath and Black Common.

There is no specific conservation measures aimed at *D. spurium* and the Action Plan remains to be written. Habitat condition clearly is crucial and management is needed to reverse the spread of scrub and trees and other deleterious floristic changes. The pervasive effect of airborne pollution is difficult to address, but there is increasing awareness of the damage that ammonia can cause to habitats such as heathland and this has led to international agreements to curb emissions from 2010¹. The moss has been recorded in at least 20 English SSSIs, all of which (apart from Linwood Warren SSSI in Lincolnshire) occur in southern England. The only SSSIs where it has been confirmed in the 1990s or later are the New Forest SSSI, Fleet Pond SSSI and Woolmer Forest SSSI in Hampshire, and Povington and Grange Heaths SSSI in Dorset. It is currently listed as Vulnerable on the revised British Red List on the basis that the rapid decline is a result of a reduction in habitat quality.



Dicranum spurium

¹ These are the UNECE Protocol to Abate Acidification, Eutrophication and Ground-level Ozone ('Gothenburg Protocol') and the National Emission Ceilings Directive (2001/91/EC).

M

DICRANALES

Dicranum undulatum

Waved Fork-moss

VU

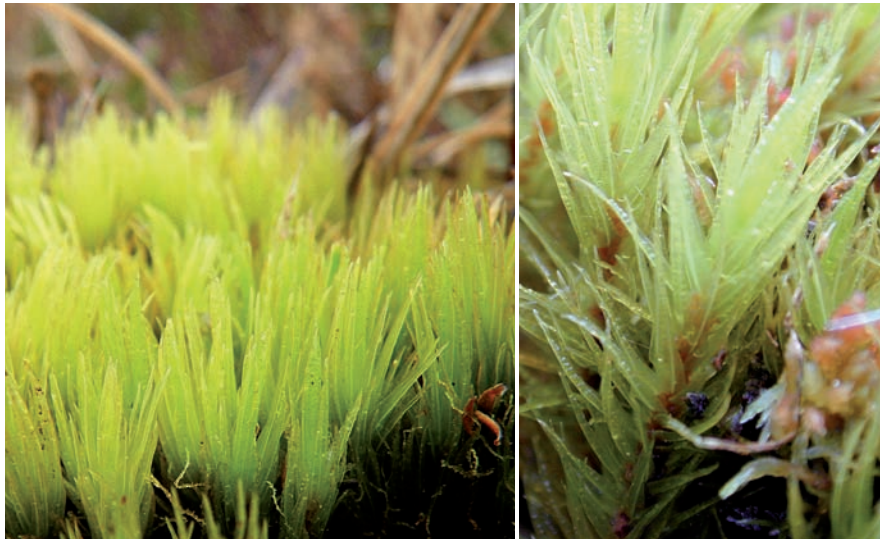
BAP; NS

No change

This species, formerly known as *D. bergeri*, is a moderately robust yellowish or light olive-green moss with shoots to 15 cm tall, although often much less. Shoots are typically tightly packed together so forming dense tufts or sometimes large hummocks. The narrow tapering leaves, ending in a blunt point, are erect when moist and little altered when dry and are transversely wrinkled (hence the specific name *undulatum*). Other *Dicranum* species, particularly *D. bonjeanii*, have obviously wrinkled leaves so care is needed in identification. The moss is dioicous and sporophytes are rare. Asexual propagules are unknown and it behaves as a perennial stayer.

It is characteristic of lowland raised bogs that are fed by rainwater, growing amongst *Sphagnum* species. Exceptionally it is found in other wetlands such as boggy moorland. Other associated bryophytes include *Aulacomnium palustre*, *Odontoschisma sphagni* and *Polytrichum strictum*.

A member of the Circumpolar Boreo-Arctic Montane element, *D. undulatum* is widespread in C, N and E Europe but absent from many southern countries. Elsewhere it is known from



TOP: *Dicranum undulatum* on a bog with tiny liverworts creeping between the shoots.

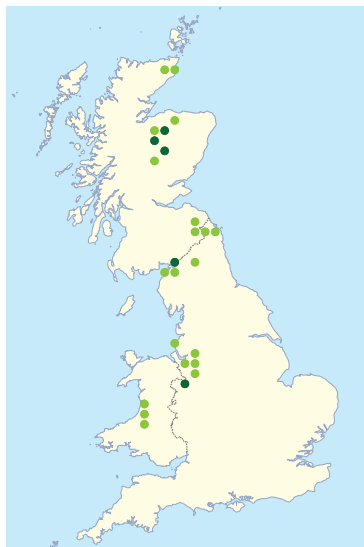
Photo: David Genney (Scotland). BOTTOM LEFT: The hummock-forming *Dicranum undulatum*.

Photo: David Genney (Scotland). BOTTOM RIGHT: The transversely undulate leaves of *Dicranum undulatum* on Glasson Moss, Cumbria. Photo: Ron Porley.

Asian Russia, C Asia and N America. In the BI it is known from Ireland (probably extinct), Scotland, Wales and England. The earliest British record is attributable to W. Wilson (1799–1871) who collected it in 1841 at Knutsford Moor in Cheshire, a classic site that once supported a range of very rare relict bryophytes, but which was drained in the early 20th century. Whether the plant survives in Cheshire today is uncertain; it was last definitely recorded on Wybunbury Bog, Cheshire, in 1965 by H. J. H. Birks. Wilson also found it in

1842 in S Lancashire at Woolston Moss and Risley Moss, but the last record from that county is 1968. A similar scenario holds for N Northumberland, where *D. undulatum* was found by bank clerk J.B.Duncan (1869–1953) in 1928, and was last seen in the county in 1930. Today *D. undulatum* is known for certain from Glasson Moss in Cumbria and from one site in Shropshire, Whixhall Moss.

Recorded from a total of about 17 localities in five English counties, there is evidence that it was once more widely distributed in Britain, with subfossil material discovered in East Anglia and Somerset (Dickson, 1973); major fragmentation of the range of *D. undulatum* took place during the last 2,500 years, largely through the destruction of bogs. Many modern occurrences persisted well into the 1960s, but this appears to have been a pivotal period and from then on populations declined. Drainage, peat extraction, scrub encroachment and afforestation have taken their toll and in some instances continue to do so. Fire is another threat although given time it may recover; a BBS visit to Whixall Moss, Shropshire in 1960, noted that much of the site had been damaged by fire. When the BBS returned in 1992, *D. undulatum* was re-found scattered across the Moss, especially in an area of undisturbed peat known as the Cranberry Beds where frequent hummocks of *D. undulatum* have developed amongst senescent heather stems. It has vanished from other Shropshire sites, for example last being seen at Clarepool Moss SSSI in 1982.



Dicranum undulatum

It has been discovered at several ‘new’ localities elsewhere in Britain, but further survey in the Shropshire and Solway Mosses is a priority. Wedholme Flow SSSI, Cumbria, was until 2004 commercially exploited and largely inaccessible to the public. The last record of *D. undulatum* from here was made in 1957 by D.A.Ratcliffe (1929–2005). The mineral rights over Wedholme Flow, including Thorne and Hatfield Moors, were bought by *EN* and an ambitious restoration programme undertaken costing the British taxpayer £17.3 million. Restoration works, completed in 2007, turned this part of the Flow from an unfavourable declining condition to one that is now recovering. The area comprises one of four mires designated under the South Solway Mosses SAC.

There is no conservation action directed at *D. undulatum*. It was added to the UK BAP in 2007 but as yet there is no published Action Plan. Priority actions should include targeted survey of historic sites, monitoring of extant populations and site condition and consideration of translocation, particularly on restored mires if populations do not recover naturally. Material should be incorporated into the *ex situ* threatened bryophyte facility at RBGK. A large proportion of the sites where *D. undulatum* was recorded during the 1950s and 1960s are SSSIs and efforts should be made to improve their condition. The two extant English populations are within Glasson Moss SSSI and South Solway Mosses SAC, and Fenn’s, Whixall, Bettisfield, Wem and Cadney Mosses SSSI/SAC. The moss has clearly undergone a marked decline, as has the quality of its habitat, and it is therefore classified as Vulnerable on the revised British Red List.

*Didymodon cordatus***Cordate Beard-moss**

EN

WCA; NR

Upgraded

This moss is a small dark green or brownish-green acrocarp with rigid shoots 5–10 mm tall. It forms dense turfs or scattered shoots, often partially buried by soil and overgrown with crustose lichen. When dry the broadly triangular, incurved, slightly concave leaves embrace the stem, but when moist they spread widely. It is dioicous and only female plants are known in Britain. It produces tiny spherical gemmae in the axils of the upper leaves and behaves as a pioneer, with a reliance on asexual propagules for population continuance.

A coastal plant, it grows on thin sandy soil over Greensand in full sun, typically on moderately steep south-facing cliffs or banks where the soil is dry and crumbly but stabilized by crustose lichens such as *Collema tenax*, *Fulgensia fulgens*, *Placynthium nigrum* and *Toninia caeruleonigricans*. Associated bryophytes include *Aloina aloides*, *Bryum dichotomum*, *Pseudocrossidium revolutum* and *Tortula atrovirens*.

A member of the European Southern-temperate element, it is widespread in southern Europe, extending N to Germany and Belgium and E to the Crimea, the Caucasus and Turkey. In the BI it is confined to one locality in southern England, at Saunton on the N Devon coast.



ABOVE LEFT: A turf of moist *Didymodon cordatus* on a crumpling cliff face.

Photo: Michael Lüth (Germany).

ABOVE RIGHT: A close-up of moist shoots of *Didymodon cordatus* showing the spreading, broadly triangular leaves.

Photo: Jan-Peter Frahm (Germany).

BELOW LEFT: A turf of *Didymodon cordatus* in the dry state. Photo: Jeff

Duckett (Germany).

It was first discovered here by the pharmaceutical chemist E.M.Holmes (1843–1930) in 1903, on a wall-top, which has long since disappeared. It was later found by the Sussex bryologist W.E.Nicholson (1866–1945) on the sea-cliffs nearby in 1916 where it survives to this day. A small outlying population also occurs on a roadside bank above the sea-cliffs.

The sea-cliff population is in the Saunton to Baggy Point SSSI. The outlying roadside bank population is just outside the SSSI, and potential threats include road maintenance and damage by passing vehicles. The more extensive population on the sea-cliff below may be at risk from excessive coastal erosion, although natural soil slippage provides fresh substrate for colonization. Conversely, coastal protection schemes, if considered for this part of the coast, could put *D. cordatus* at risk. Other than being fully protected under the WCA 1981, there is no specific conservation action for the plant and oddly it is not a priority UK BAP species. There is a sound case for this species to be added to the *ex situ* threatened bryophyte facility at RBGK. A reassessment of the threat status has resulted in it being upgraded from Vulnerable (Church *et al.*, 2001) to Endangered on the revised British Red List by reason of the very small, sole population in England.



Didymodon cordatus

M

POTTIALES

Didymodon glaucus

Glaucous Beard-moss

CR

BAP; WCA; NR

No change

This species is a small greyish-green (hence *glaucus*) turf-forming moss up to 3 mm tall. The narrow tapering leaves are curled when dry and spread when moist. It is dioicous and sporophytes are unknown throughout its range; only female plants have been found in Britain. Specialized asexual propagules are present on modified rhizoids in the upper leaf axils, appearing as heavily pigmented chains (moniliform) of up to eight rounded gemmae. Protonematal gemmae (of similar morphology to the axillary gemmae) are also present in culture and nature. It behaves as a colonist, with a moderately long lifespan, low growth rate and a high reliance on asexual propagules for population maintenance. Short distance dispersal of gemmae may be mediated by rain wash and possibly molluscs (Porley, 2007).

It is a pioneer of bare chalk and limestone banks, in crevices and on talus-covered ledges and on accumulated talus at the foot of chalk cliffs. It thrives in low light intensity and can grow in deep shaded recesses. Few bryophytes can tolerate such low light levels but *Eucladium verticillatum* may be present; in niches receiving more light *D. tophaceus*, *D. rigidulus* and *Pohlia melanodon* have been recorded as close associates.



LEFT: *Didymodon glaucus* on chalk with heavily pigmented (purplish) protonemal gemmae (bottom of picture). RIGHT: The abandoned chalk-pit habitat of *Didymodon glaucus* in Wiltshire.

Photos: Ron Porley.

A member of the European Temperate element, it is known from 12 European countries with its stronghold in Germany, Austria, the Czech Republic and northern Italy. In many other countries it is known from only one or two localities and is listed as vulnerable in Europe (ECCB, 1995). Elsewhere it is known from Turkey, Mongolia and old records from Japan and China. In the BI it is restricted to England. The first record was in 1908 by W.E. Nicholson (1866–1945) from a chalk bank near Shoreham, discovered during one of his habitual bicycle excursions around Sussex. On a warm March day in 1912 he took the train to Steyning and then cycled to Washington Common, and as his diary understatedly records “*rode back to Brighton gathering a small quantity of Didymodon glaucus near Shoreham on the way*”. This second English locality was from a small overgrown chalk pit. There are no subsequent Sussex records. There is also a report by R. Barnes (1851–1918) of the plant on Carboniferous limestone rocks near Richmond in Yorkshire in 1914, but there is no specimen and it has not been found in the district since.

It was not seen again in England until 1961, when J. Appleyard (1906–1989) discovered it in a disused chalk pit by a green lane near Swindon in Wiltshire. Other bryologists duly came to admire this rare moss and additional small colonies were detected on chalk banks beside the green lane. But, by 1978, the moss had apparently vanished. In the same year, H.L.K. Whitehouse (1917–2000) took soil samples from the chalk pit in which he subsequently discovered a chain of four gemmae; from three of the gemmae he succeeded in culturing *D. glaucus* on agar. The moss had not disappeared but was lying ‘dormant’ in the diaspore bank. Over the years the Wiltshire population fluctuated. A few scattered stems persisted along the green lane, but the chalk pit was becoming overgrown with vegetation. By 1980, a tree had fallen into the pit bringing debris down over the chalk face, obliterating the plant. During this period, tipping of rubbish also became a problem. The neglect was turned around largely by the sustained efforts of HLKW and others when, in 1978, contact

was made with the NCC. Protracted negotiations culminated in re-notification of the site as Bincknoll Dip Woods SSSI in 1987, encompassing the chalk pit within the new site boundary. In 1988, a team cleared the pit of debris and rubbish and exposed much of the original chalk face. Later that year, HLKW was able to confirm that the moss had colonized the freshly exposed chalk, ostensibly from gemmae in the diaspore bank. By 1989, a colony of about 15 cm² had established.

This was pioneering work in the field of bryophyte conservation and is the first documented example of successful intervention to prevent what would otherwise have been certain extinction of a bryophyte in Britain. In 1992, the plant received full protection under the WCA 1981 and in 1993, before the UK BAP for *D. glaucus* had been published (1995), *EN* initiated a monitoring programme. The colony size in 1993 was estimated at 266 cm², but once again it began to decline. In 2003, the chalk face was re-excavated to provide fresh exposures, resulting in the rapid establishment of many new colonies, and by 2007 the area had increased to 1,080 cm².



Didymodon glaucus

The primary threat to the species is neglect. Encroaching vegetation needs to be carefully removed by hand at frequent intervals. Intervention, ideally with a digger, is needed at least once every decade to clear debris and create fresh exposures of chalk. The site condition and the status of the population should be monitored every two years. A single small population is at an extremely high risk of extinction, thus in 2007 *NE*, in partnership with the Sussex WT and the landowner, cleared the overgrown chalk pit near Shoreham where Nicholson had gathered *D. glaucus* in 1915 (Porley, 2007). If the moss fails to appear 'naturally', it is anticipated that translocation trials can begin using *ex situ* material sourced from Wiltshire in the form of cultures grown on chalk fragments or as inoculates (Pressel & Duckett, 2004). Material in axenic culture is held in the *ex situ* threatened bryophyte facility at RBGK.

Given the restricted area of occupancy and extent, together with the single location and a projected decline in habitat quality, *D. glaucus* is classified as Critically Endangered on the revised British Red List.

M

DICRANALES

Ditrichum cornubicum

Cornish Path-moss

EN

BAP; WCA; NR

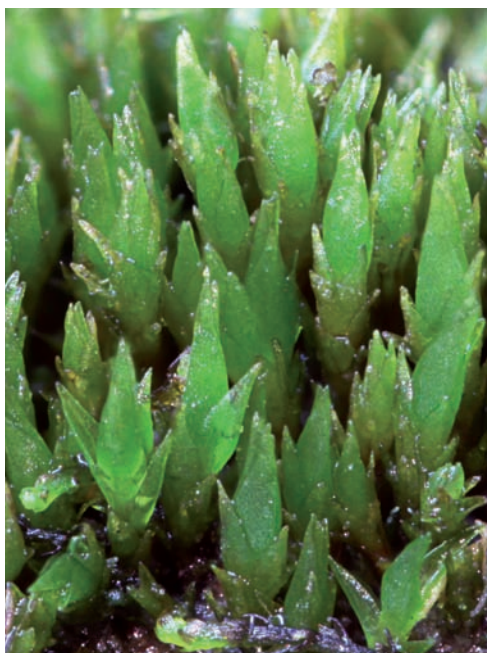
No change

This is a very tiny moss, forming dull-green loose tufts or scattered shoots 1–5 mm tall. The blunt-tipped leaves, which are more crowded towards the shoot apex, are held tightly against the fragile stem when dry and spread when moist. It is dioicous but only male plants

have been found in Britain and sporophytes are unknown. Asexual propagules are present in the form of spherical multicellular rhizoidal tubers and these often develop on rhizoids in the lower leaf axils. Chains of filamentous ‘brood cells’ also occur on the protonemata and protonematal gemmae are produced in culture. The species can be confused with two other species (*D. lineare* and *D. plumbicola* – the latter species is very close to *D. cornubicum* and molecular analysis is currently underway to elucidate the precise relationship) but the form of their rhizoidal tubers enables separation (Arts, 1994). This species behaves as a colonist, with the above-ground shoots disappearing in the dry summer months and resuming growth in late winter to early spring.

This moss grows on compacted acid (pH 5.5–5.8) loamy or humic metal-rich well-drained soil on sparsely vegetated ground, often by or on old paths and tracks but occasionally on banks and, rarely, in the crevices of an old wall. The soils are rich in copper, with concentrations of 151–1400 p.p.m. It does not tolerate competition and, as the metals are slowly leached out by weathering, other mosses, including *Ceratodon purpureus* and *Rhytidiadelphus squarrosus*, can colonize, ousting *D. cornubicum*.

A member of the Oceanic Temperate element, it is endemic to the BI, known from England and Ireland (a small population was discovered in 2006 in W Cork). It is an example of a species that shows a narrow geographical range with a small population size with high habitat specificity. It has been suggested that it is an endemic induced anthropogenically by virtue of the long history of industrialization in Britain (Tan & Pócs, 2000). In England, the first specimen was collected in 1963 on mine spoil from a roadside at Lanner, near Redruth in W Cornwall, by J.A. Paton, and in 1965 she collected it again near Minions,



Ditrichum cornubicum with shoots that barely reach 5 mm tall. Photo: David Holyoak.



A hands-and-knees search for *Ditrichum cornubicum* at Minions on the edge of Bodmin Moor, Cornwall. Photo: Ron Porley.

a disused copper mine north of Liskeard on the SE edge of Bodmin Moor at 280 m in E Cornwall. It was not until 1976 that the enigmatic plant was published new to science (Paton, 1976) under the name *D. cornubicum* (after *Cornubia*, Latin for Cornwall). Many years later, in 1997, another population was found near Minions, at Crow's Nest, by D. T. Holyoak.

The plant has never been re-found at Lanner, probably as a result of road maintenance works. Nevertheless it survives at Minions, within the Phoenix United Mine SSSI, and at Crow's Nest SSSI; both sites were notified for this and other heavy metal specialist bryophytes and are combined under the Phoenix United Mine and Crow's Nest SAC. The SAC also supports several other notable metallophytes including the Red Listed *Cephaloziella massalongi* (page 74), *C. nicholsonii* (page 75) and *Scopelophila cataractae* (page 157), and the Nationally Rare *D. lineare* and the Nationally Scarce *Pohlia andalusica*.



Ditrichum cornubicum

It is fully protected under the WCA 1981, was one of the first bryophytes to have a UK BAP and is one of four British species on the IUCN Global Red List of bryophytes. It has been monitored regularly at both SSSIs since 1998. During 2000–2003 the populations reached very low levels as a result of competition from grasses, herbs and other mosses due to high nutrient input from sheep dunging. Sheep were apparently resting on the tracks and other bare ground during the winter months, possibly because these areas retained warmth for longer. Fencing was erected at Phoenix United Mine to exclude sheep from the occupied areas and the top 2–4 cm of soil plus vegetation was stripped off using a shovel. After a year there was a rapid population expansion of the moss from the diaspore bank, confirming the technique as an effective management tool. Sub-populations are dynamic, but at its peak in 2004/5, the area occupied by *D. cornubicum* in the stripped plots alone was estimated to be some 3,500 cm² at Phoenix United Mine and 5,100 cm² at Crow's Nest.

It is important that this very rare moss continues to be monitored annually and that competing vegetation is removed when necessary. The periodicity of top-soil stripping is partly determined by how long the asexual propagules remain viable. Experimental work should be initiated to provide such data, but preliminary data suggest that a viable diaspore bank exists for at least two years, and is likely to be more. Since only male plants are known, it is reasonable to suppose that all populations in Cornwall represent a single clone; this could be tested by DNA fingerprinting techniques as a first step in any future translocation programme. Axenic cultures and cryopreserved material is held in the *ex situ* threatened bryophyte facility at RBGK. Given the small range and the propensity of the habitat to deteriorate quite rapidly, the plant is classified as Endangered on the revised British Red List.

Ditrichum subulatum

Awl-leaved Ditrichum

VU

BAP; NR

Upgraded

This species is a soft, slender, yellow-green turf-forming moss with erect shoots to 8 mm tall. The silky leaves are very narrow, tapering to a long fine point or subula (hence ‘*subulatum*’) filled largely by an excurrent nerve; the uppermost leaves tend to curve to one side and are wavy when dry. It is monoicous and sporophytes are common. Specialized asexual propagules (tubers) are present on the rhizoids in the form of a spirally twisted row of cells. It behaves as a colonist.

It is a coastal plant on loose, crumbly, acid sandy, clayey or loamy soils, often on steep banks of creeks in light shade from overhanging trees and amongst exposed tree roots. It also occurs on earthy or stony banks by lanes and roadsides in warm sunny positions. Associated bryophytes include *Cephaloziella turneri*, *Dicranella heteromalla*, *Diplophyllum albicans* and *Epiterygium tozeri*.

A member of the Mediterranean–Atlantic element, it is widespread in the Mediterranean region extending N along the Atlantic coast to western France and southern Britain and E to Turkey. Elsewhere it occurs in Macaronesia and N Africa (Algeria, Morocco and Tunisia). In the BI it is known from S Wales (recently discovered) and the SW of England. The earliest English report is by J. S. Tozer (1790–1836) in 1852 from Trethowell, near Truro in W Cornwall. It was collected by a number of bryologists from this area including W. Curnow (1809–1887), J. Ralfs (1807–1890) and R. V. Tellam (1826–1908) in the late 19th century and it was also found in E Cornwall for the first time in 1867 by F. Brent. Many of the finds were from the creeks and lanes around the Falmouth estuary and the Cornish–Devon border where the Rivers Tamar and Tavy drain a little farther east, particularly around Saltash. Soon after it was found in S Devon, from Tamarton Foliot, Bickleigh Vale and St Budeaux, all within the environs of Plymouth, by E. M. Holmes (1843–1930) although the exact dates



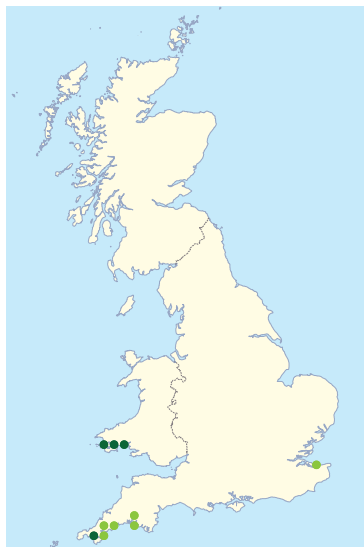
LEFT: The delicate moistened shoots of the Mediterranean–Atlantic moss *Ditrichum subulatum*.

Photo: Des Callaghan. RIGHT: Old dehiscent capsules of *Ditrichum subulatum* on a dry, crumbly bank.

Photo: Ron Porley (Portugal).

are not known. The plant has not been found in Devon since. Similarly, a record from E Kent some distance from the coast, at Honey Wood (north of Canterbury), collected by P.R. Bell in 1946, has never been seen since.

In Britain this Nationally Rare plant has been recorded in a total of 14 10km squares (hectads). In England it has been recorded in about 30 localities in ten hectads, and some 26 of the localities are, or were, in Cornwall. Many of the Cornish records were made by J.A. Paton in the 1960s during her work on the Cornwall bryophyte flora, but occurrences have apparently dwindled to about six localities in the 1990s to four post-2000 in two hectads. Populations occur near Gweek and along creeks that drain into the River Helford. It is unclear why the moss has declined; mild wet winters and dry summers would be expected to benefit a plant belonging to the Mediterranean–Atlantic element. Nevertheless, this moss has apparently always been rare and in small quantity (Paton, 1969). Some of the lane and roadside occurrences may have been eliminated through highway maintenance and development, and possibly by tourism pressure, recreation and commercial operations. Boat moorings and water pollution may also have an impact on populations.



Ditrichum subulatum

Most of the Cornish populations are within three SSSIs (Merthen Wood SSSI, Tamar–Tavy Estuary SSSI and Upper Fal Estuary and Woods SSSI) and within two SACs (Plymouth Sound and Estuaries SAC and Fal and Helford SAC). Added to the UK BAP list in 2007, there is as yet no published Action Plan but axenic cultures are held in the *ex situ* threatened bryophyte facility at RBGK. There is the possibility that the plant has been overlooked and priority should be given to targeted survey of its historic localities, searching potential new habitat by creeks and estuaries, and identifying potential threats. It was formerly classified as Near Threatened (Church *et al.*, 2001) but during the recent revision it was added to the British Red List as Vulnerable in recognition of its very restricted range combined with evidence of a decline.

L

MARCHANTIALES

Dumortiera hirsuta

Dumortier's Liverwort

VU

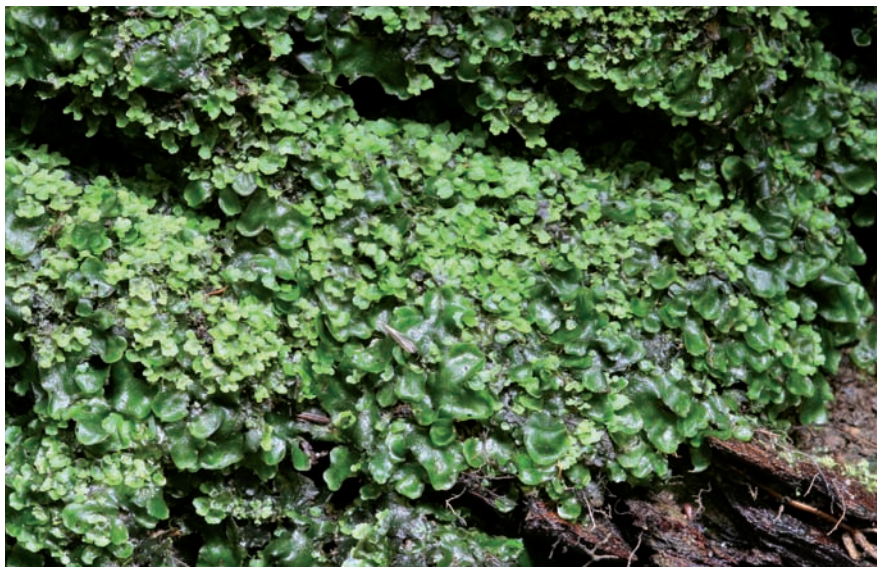
BAP; NR

No change

This dark green, semi-translucent, thalloid liverwort, named in honour of the Belgian bryologist and politician B. C. J. Dumortier (1797–1878), is up to 12 cm long and 2 cm wide. The thalli are often forked and it can form extensive hanging mats. It differs from all other Marchantiales in its upper surface appearing to lack any pores or network of lines and in having scattered hairs (hence *hirsuta*) that are particularly evident on the thalli margins.

It can form monoicous or dioicous populations, with male plants more commonly recorded than females. The lobed receptacle of the female plant is held on a stalk up to 5 cm tall, whilst the disc-shaped male receptacle is on a much shorter stalk, about 1 mm long. Sporophytes are occasional and asexual propagules are unknown. It has relatively large spores and behaves as a long-lived shuttle, with thalli persisting for many years.

It grows on neutral or mildly basic, shaded, humid or constantly moist, often dripping, rocks or banks in wooded ravines, or on sheltered banks by rivers, streams and waterfalls,



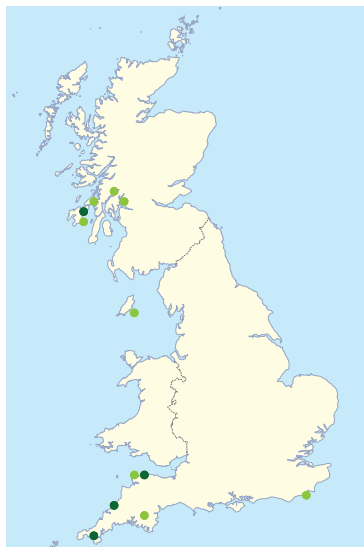
A mat of dark green *Dumortiera hirsuta*, photographed in Cornwall, contrasts with the pale green liverwort *Conocephalum conicum*. Photo: Richard Lansdown.



LEFT: The delicately reticulated thallus of *Dumortiera hirsuta* showing the hairy margins.
RIGHT: The thalloid liverwort *Dumortiera hirsuta* at Fairlight Glen, Sussex, with female receptacles. Photos: Ron Porley.

and sometimes in caves and shady recesses. It is commonly associated with *Conocephalum conicum*, *Thamnobryum alopecurum* and occasionally the oceanic liverwort *Jubula hutchinsiae*.

A member of the Oceanic Southern-Temperate element, it occurs in Belgium, France, Spain, Portugal, Italy and Greece. It is listed as rare in Europe (ECCB, 1995). Elsewhere it is known in Macaronesia, tropical Africa, Asia and S America, the Philippines, Hawaii and Tahiti. It is essentially a tropical species and the BI is on the northern edge of its range. In the BI its stronghold is in Ireland, although here too it appears to be declining (Lockhart, Hodgetts & Holyoak, 2012), and it also occurs in Scotland and England. The first English record dates from around 1841–42, collected by J. Ralfs (1807–1890) and W. Borrer (1781–1862), from Coombe Martin in N Devon, with the last record from here around 1909. Together with an old record (mid-20th century) from Holne Bridge on the River Dart, in S Devon, they represent the only known losses in England; it is still known at its other historical sites in Cornwall, N Devon, E Sussex and on the Isle of Man. The locality in E Sussex for *D. hirsuta*, the most easterly in England, is Fairlight Glen, near Hastings, a deep frost-free Wealden sandstone ravine that incises a course down to the coast. The liverwort has been known from here as far back as 1883, first collected by Revd. E.N. Bloomfield (1827–1914). At the head of the Glen, percolating ground water trickles over shimmering curtains of *D. hirsuta* and this has attracted a succession of bryological luminaries to what seems to be the most visited site for those wishing to acquaint themselves with *D. hirsuta*. It is within Hastings Cliff to Petit Beach SSSI and Hastings Cliffs SAC.



Dumortiera hirsuta

There is no specific conservation action aimed at this plant and there is currently no published UK BAP. It occurs within a total of four English SSSIs and two SACs (two SSSIs in Cornwall (Merthen Wood SSSI and St Nectan's Glen SSSI, the latter within Tintagel-Marsland-Clovelly SAC), one in Devon (Watersmeet SSSI) and one in E Sussex (Hastings Cliffs to Petit Beach SSSI, within Hastings Cliffs SAC). There has been no systematic review of the threats at individual sites but severe pollution of the stream (agricultural run-off) has been noted at Fairlight Glen, although this has not affected the bryophytes which are upstream of the offending source (Rose, Stern & Matcham, 1991). Other more general concerns include changes in humidity due to felling of trees and thinning of the tree canopy, which are both potentially damaging to this sensitive oceanic species. The moss has been recorded from a total of six 10 km squares in England, and post 1990 is extant in five, thus it is classified as Nationally Rare. Apart from the two losses the plant is remarkably persistent and evidence of long-term decline is lacking. However, no new 10 km square records have been found in recent years. Given the very restricted range of this liverwort in Britain, and its presence in less than ten locations, it is categorized as Vulnerable on the revised British Red List.

*Ephemerum cohaerens***Clustered Earth-moss**

EN

BAP; NR

Downgraded

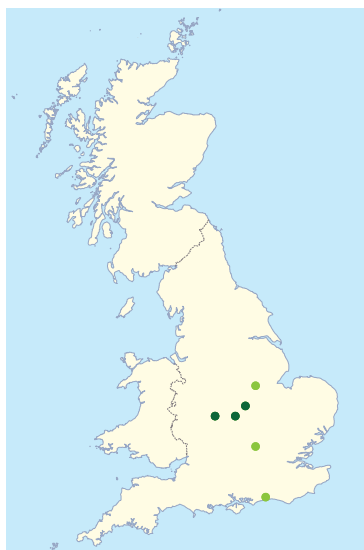
This minute moss arises from a green persistent protonema, with scattered leafy shoots barely more than 1 mm tall. The narrow leaves have a nerve that extends into the finely pointed apex and the upper margin is toothed (microscopic examination is necessary to separate it from similar species). It is monoicous and the almost spherical sessile capsules are nestled amongst the upper leaves. Specialized asexual propagules are present in the form of large lipid-rich tubers and short-distance dispersal may occur by protonemal fragmentation. Sexual reproductive effort is high, rapidly producing an extensive protonemal mat followed by leafy shoots and sporophytes in the autumn. It behaves as an 'episodic' annual shuttle species.

The plant is an ephemeral (hence the generic name) moss of acid to neutral, bare, damp, silty mud and disturbed soils at the margins of ponds, lakes and reservoirs. It is particularly characteristic of the 'draw-down' zone of water bodies, where mud is exposed as water levels recede in the summer months. It is typically found with a range of ruderal flowering plants such as Water Mint, Silverweed and Creeping Cinquefoil and the bryophytes *Aphanorhegma patens*, *Bryum klinggraeffii*, *Dicranella varia* and *Riccia cavernosa*. In Europe, the habitat range is broader, including river flood plains and depressions in arable fields and pastures.

A member of the European Temperate element, it is scattered throughout W and C Europe and listed as endangered (ECCB, 1995). Elsewhere it is known from the Azores, Turkey, China, Japan and N America. In the BI it is known from Ireland (seven recent localities) and England. The earliest English report, in 1896, is attributable to W.E. Nicholson (1866–1945) from the margin of Swanbourne Lake in W Sussex: "*only gathered on one occasion and then very sparingly*" (Nicholson, 1908). There is also a tantalizing collection by an anonymous recorder made sometime before 1941 from Leicestershire with Rutland, in the same 10 km



Ephemerum cohaerens near Slijk Ewijk on the Dutch Rhine floodplain. Photo: Dick Haaksma (Netherlands).



Ephemerum cohaerens

square in which Knipton Reservoir occurs and where the plant was found many years later by A. J. E. Smith in 1961.

The moss has been recorded in a total of six localities in five English counties, but post-2000 it is known from just two counties. It was found new to Northamptonshire in 2002 by N. G. Hodgetts at both Welford and Daventry Reservoirs. At Welford it occupied a zone about one metre wide and over 20 metres long, although in 2003 much of the population was present as a protonemal mat. At Daventry it was abundant over several square metres on silty mud on the lower shore. In 2004, it was also found new to Worcestershire by M. Lawley and others at Bittell Reservoirs SSSI (a site also important for migrating birds), in the Upper Arrow Valley. It has not been seen any later than the early 1960s at the other three localities despite searching – Swanbourne Lake (within Arundel Park SSSI) in W Sussex, Tring Reservoirs in Hertfordshire and Knipton Reservoir in Leicestershire. It may yet be re-found if the habitat remains suitable at these sites (although water levels are kept artificially high at one site).

It is notable that the recent sites are new localities; this suggests that the plant may not persist for very long at any one site (unlike populations in the Netherlands). The spores (up to 70µm) are presumably too large for effective long-distance dispersal, and birds may carry spores or protonemal fragments from site to site. The recent report of tubers raises the possibility of an alternative means of perennation if the mud is inundated by water before the spores have been able to mature (Pressel, Matcham & Duckett, 2005). Reservoir and lake margins are typically prone to disturbance, undoubtedly important in the life-history of the moss. In such a rare sporadic plant, a decline is difficult to demonstrate, and given its small size and ephemeral nature it is possible that it is overlooked.

The species was added to the UK BAP in 1997 but was given a brief ‘species statement’ rather than a detailed Action Plan since it had not been seen in the wild for more than ten years. Nevertheless, it was one of the target species in the 2002 reservoir bryophyte survey funded by EN/NE and this led to its discovery in Northamptonshire. The moss is currently known from only one SSSI, yet conserving such a rare sporadic plant is problematic and the SSSI framework should be regarded as part of a wider landscape scale solution. Collaboration between reservoir owners is crucial to develop management plans that cater for the plant’s specific needs, in particular the provision of a draw-down zone and control of invasive vegetation (which would benefit a range of bryophyte reservoir specialists). The impact of recreational activities such as angling and boating, which often leads to high water levels all year round, needs to be resolved. Currently *E. cohaerens* is not held in the *ex situ* threatened bryophyte facility at RBGK.

In Britain, the plant has a very restricted range and populations fluctuate, but the recent discoveries since 2000 have moved it out of the Critically Endangered category into Endangered on the revised British Red List.

M

HYPNALES

Eurhynchiastrum pulchellum

Elegant Feather-moss

EN

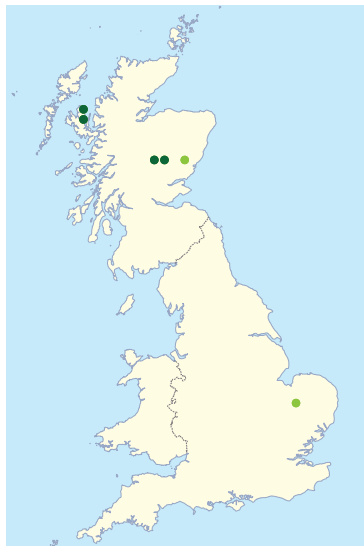
BAP; NR

No change

This is a petite pleurocarp (*pulchellum* means small and beautiful) forming green or yellowish-green rough mats with many blunt-tipped short branches arising from the



Eurhynchiastrum pulchellum forms rough mats with numerous short branches with blunt-tipped leaves. Photo: Michael Lüth (Italy).



Eurhynchiastrum pulchellum

creeping primary stem. Stem and branch leaves differ in size and shape; the former are larger, more or less triangular and taper to a point, whilst the smaller branch leaves are often rounded at the tip. The leaves, which are lightly pleated lengthwise, have a nerve that ends well below the apex and a margin that is finely toothed. The variability in form has caused much confusion until M. O. Hill resolved the situation by demonstrating that of the three varieties currently recognized in Europe all the material from the BI is variety *diversifolium* (Hill, 1993). It is dioicous and sporophytes are not known in Britain. Specialized asexual propagules are unknown and it behaves as a perennial stayer.

It is a plant of calcareous grassland, amongst sparse short grasses, herbs and bryophytes, which is kept open by disturbance, such as rabbit grazing or turf cutting. Associated bryophytes include *Barbula unguiculata*, *Campyliadelphus chrysophyllus*, *Dicranum scoparium*, *Encalypta vulgaris*, *Rhytidium rugosum* and the liverwort *Barbilophozia barbata*. The habitat in Scotland is quite different as the plant grows on base-rich rocks in the mountains.

A member of the Eurosiberian Boreo-Arctic Montane element, it is widespread but scattered in Europe, mostly in montane areas from the Iberian Peninsula in the S to Arctic Svalbard in the N. Elsewhere it is known from the Canary Islands, W Asia, Afghanistan, N and S America and Greenland. In the BI it occurs in Ireland (possibly extinct), Scotland and formerly England. It has been suggested that *E. pulchellum* may be a Devensian relict with a wider range in the last glaciation (Dickson, 1973), which may explain its occurrence so far south. Known in Scotland since the late 1800s, it was not discovered in England until 1950, by F. Rose (1921–2006) at Lakenheath Warren on the Suffolk Brecklands. In 1951, Rose returned to the site, accompanied by E. C. Wallace (1909–1986), R. A. Boniface (1913–1985) and P. J. Wanstall (1924–1993), and found several scattered patches ranging from 2.5–8 cm across, barely occupying an area of 20 m in diameter amongst other mosses in short, dry calcareous grassland in an area from which turf had been removed to expose bare chalk in the 1940s (Rose, 1952). It was subsequently found at three other spots near

The Lodge. In 1978, H.L.K. Whitehouse (1917–2000) and C.D. Preston visited the site to assess its status. Although they found two small patches in its original locality, it had apparently disappeared from the other areas where it was known. By 1980, there was just one small patch. A tiny fragment was taken for culture in Cambridge but unfortunately this material no longer exists. By comparison to the vegetation in 1950, it was clear that there had been marked floristic changes: Bracken, Sand Sedge and tall grasses dominated the area where the moss had formerly occurred and pines had become established. Although the removal of the pine trees was negotiated, it was too late; by 1990 the moss had vanished (Preston, 1994).

The English population of *E. pulchellum* was a victim of changing land use, economics and neglect. Sheep were grazed on Lakenheath Warren up to 1956, and rabbits, formerly abundant (hence the site name ‘warren’), had been decimated by myxomatosis. Faced with a lack of both grazing and disturbance, less competitive plants all but disappeared, intolerant of shade and litter accumulation, and this occurred despite Lakenheath Warren being designated an SSSI in 1954. It is a familiar story. The presence of *E. pulchellum* in Scotland at about four localities means it remains on the revised British Red List as Endangered.

M

DICRANALES

Fissidens curvatus

Portuguese Pocket-moss

EN

BAP; NR

Upgraded

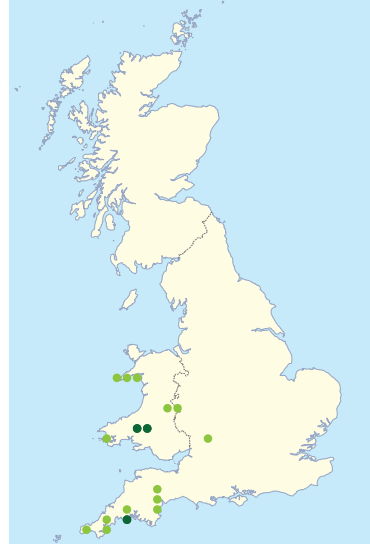
Fissidens (meaning ‘split tooth’, alluding to the peristome teeth surrounding the capsule mouth) are unique amongst mosses in that each leaf has a ‘pocket’ on its forward edge (the vaginant lamina), which the leaf immediately above it neatly slots into, creating shoots that resemble miniature ferns. Formerly known as *F. algarvicus*, it was initially described by the German botanist H. Solms-Laubach (1842–1915) under this name from material collected at Silves in the Algarve in 1866 (hence the common name), but it was later shown to be synonymous with *F. curvatus* from the Cape, South Africa, collected in 1827 by another German botanist C.F. Ecklon (1795–1868). It is a small, bright green moss forming a scattered turf with individual shoots up to 3 mm tall. It is distinguished from other small *Fissidens* with bordered leaves by its long narrow leaves that taper to a fine point. It is dioicous and sporophytes are occasional. Asexual propagules are unknown and it behaves as a colonist.

It is a plant of acid to neutral clayey soils on humid banks, including shaded roadside and lane banks, on wooded and rocky slopes and on coastal cliffs. Associated mosses include *F. viridulus* and *Epiterygium tozeri*.

A member of the Mediterranean–Atlantic element, it is globally widespread but localized in Europe where it is classified as ‘insufficiently known’ (ECCB, 1995). It occurs on the Iberian Peninsula north to the BI, Luxemburg and France and east to Greece, Bulgaria, Croatia, and Montenegro. Elsewhere it is reported from Turkey, Macaronesia, N and E Africa, N America, Mexico, S America, West Indies, China, India, Japan, Australia, New Zealand and New Caledonia. In the BI it is known from Ireland (no recent records), Wales and England. The first English record is attributed to G.B. Savery (1874–1937) who collected it in the environs of Exeter, S Devon, in 1901. The plant was last seen in Devon in 1950 when it was recorded on lane banks around Totnes during a BBS meeting. The last record for W Cornwall is 1966 and there is a single record for E Gloucestershire dated 1912. Only in E Cornwall has



The Mediterranean-Atlantic moss *Fissidens curvatus*, showing the typical narrowly tapering leaves. Photo: Des Callaghan.



Fissidens curvatus

the moss been seen post-2000, at two sites: within Talland Barton Farm SSSI, on a rocky bank in grassland by a coastal path, and at Polperro (both within the same 10km square). Most of its other localities in E Cornwall, including a population within Cudden Point to Prussia Cove SSSI, have not been seen since the mid-1960s despite recent searches. It grows in rather unremarkable habitats that are likely to be passed over by bryologists, but it is also possible that populations are transitory. Nevertheless, it has apparently undergone a marked decline from some 13 localities in a total of 11 10km squares in England to just two known sites today. Such a widespread decline may suggest climatic change, but being a member of the Mediterranean-Atlantic element and at the northern limit of its range in the BI it might be expected to expand. Although it favours shade, it is intolerant of competition, so a lack of grazing, which would normally provide open disturbed ground, may be a contributory factor in its decline. Another possibility could be pollution such as ammonia deposition. The remaining populations in England should be kept under surveillance and evaluated as a candidate for the *ex situ* threatened bryophyte facility at RBGK. In recognition of the very restricted range and continuing decline, the threat status of the plant has jumped from Near Threatened (Church *et al.*, 2001) to Endangered on the revised British Red List.

M

DICRANALES

Fissidens serrulatus

Large Atlantic Pocket-moss

VU

BAP; NR

No change

Fissidens serrulatus (for an explanation of the generic name. see *F. curvatus* *opposite*) is one of the larger species with the genus, with green turf-forming closely packed shoots up to 7.5 cm long and 7 mm wide. The numerous non-bordered leaves, arranged in two flat neat rows on opposite sides of the stem, taper abruptly to the leaf tip which is distinctly

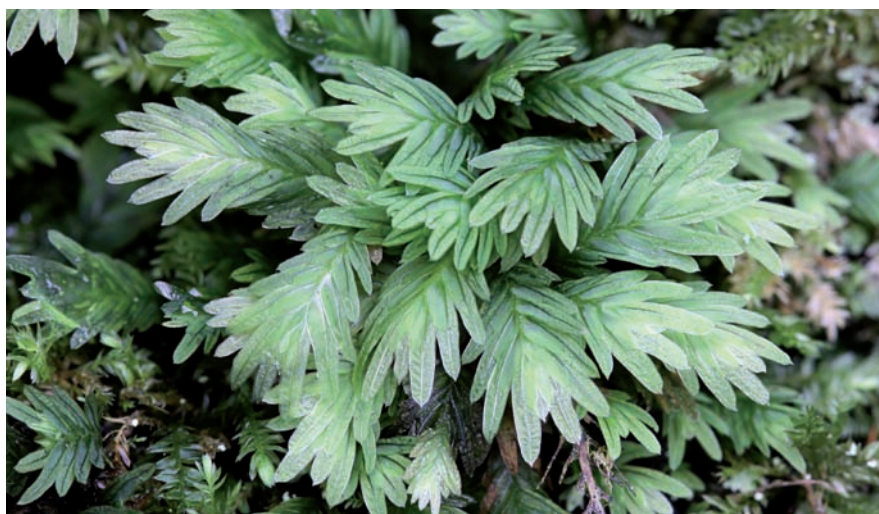
toothed (hence *serrulatus*). The diagnostic feature is the occurrence of tiny conical protruberances (mamillae) on the cells which, in the field, imparts a characteristic lustre to the leaves. It is dioicous and only male plants are known in Britain; likewise sporophytes are unknown. Specialized asexual propagules have been found in a single specimen from Devon in the form of spherical rhizoidal tubers. In Britain it behaves as a perennial stayer.

This is a moss that grows on damp, gravelly or sandy acid or neutral soils, or on rocks and exposed tree roots, typically on steep river banks in the flood zone where it is regularly inundated. It is particularly well adapted to survive in deep shade. Associated bryophytes include *Heterocladium heteropterum*, *Hyocomium amoricum*, *Isoetecium holtii* and it occasionally grows with the Nationally Scarce *F. polyphyllus*.

A member of the Mediterranean–Atlantic element, it occurs along the Atlantic seaboard from the Iberian Peninsula to the BI, and the W Mediterranean countries east to Greece, Croatia, Montenegro, Slovakia, Serbia and Turkey. Elsewhere it is known from Macaronesia and N Africa. In the BI it occurs in Ireland (seen recently at one site), Wales (no records since 1968) and SW England. The first English record was made by local botanist and market gardener W. Curnow (1809–1887) in 1867, along the Larriggan River at Castle Horneck, near Penzance in Cornwall. Curnow is fittingly commemorated by another western species, *F. curnovii* (Curnow's Pocket-moss), although this has recently been demoted to a variety



Fissidens serrulatus



A Cornish population of *Fissidens serrulatus*, a species found in deep shade by rivers.

Photo: Des Callaghan.

of *F. bryoides*. The stream at Castle Horneck was visited frequently thereafter by many bryologists, including the great Victorian bryologist H.N. Dixon (1861–1944) who was shown the plant by Curnow in 1886. Although Curnow was acutely aware of the fragility of habitats and the ease with which species can be exterminated, later collectors were not so restrained and the plant suffered from overzealous collecting at this site. In 2012, it persists at Castle Horneck, albeit in small quantity, in one main and four smaller patches along the south bank of the stream. The site receives no formal protection.

In Britain, the stronghold is along a 15 km stretch of the River Dart in Devon, from Holne to just west of Dartington. Here, the river courses through a sylvan landscape where white-water swirls past boulders and bobbing Dippers. The moss occurs in the shadiest of niches, typically sheltered by an overhanging river bank or beneath a canopy of bank-side trees. It has been admired by bryologists at this location ever since it was first found in 1910. Some of the populations occur within the Holne Woodlands SSSI and Dartmoor SAC, and others are on land owned by the NT that lies wholly within the Dartmoor National Park.

No conservation measures are specifically aimed at the plant. It was added to the UK BAP in 2007 and as yet there is no published Action Plan. Collecting is not the problem it was half a century ago or more; nevertheless the much-diminished population at Castle Horneck remains at risk and survey farther upstream of Larriggan River is a priority. Other threats include changes to water quantity and quality and loss of bank-side trees that afford shelter for this Atlantic species. Since it has a very restricted range in Britain and there is clear evidence of a decline *F. serrulatus* is classified as Vulnerable on the revised British Red List.

M

GRIMMIALES

Grimmia anodon

Toothless *Grimmia*

CR

NR

Upgraded

The genus *Grimmia*, named after the German bryologist J.F.K. Grimm (1737–1821), is a group of mosses forming cushions or patches on rock from the lowlands to the highest mountains. This species is a small, dark green moss that forms dense cushions with individual shoots to 15 mm tall but often shorter. Although quite variable, the narrow tapering leaves end in silvery hairpoints giving the cushions a greyish appearance when dry. It is monoicous and sporophytes, partially immersed in the upper leaves, are common. The capsule is attached off-centre on a short ‘S’-shaped (sigmoid) seta and it lacks peristome teeth (hence English name). The capsule mouth flares widely following liberation of the lid (dehiscence). Specialized asexual propagules are unknown and it behaves as a stress-tolerant perennial stayer.

It is normally an upland plant of basic rocks, including limestone and concrete; in other parts of its range it also occurs on siliceous rock. It establishes in crevices on exposed dry or seasonally damp sloping or vertical faces, and may occur in some quantity. It apparently tolerates pollution and elevated nutrient levels.

A member of the Circumpolar Wide-temperate element, it is scattered but rather local throughout S and C Europe extending north to Spitzbergen. It is a strongly continental species, occurring mainly in semi-arid continental interiors. Elsewhere it is known from N Africa, S, W and C Asia, N America, Mexico and S America extending south along the



Grimmia anodon showing the silver hair-points and numerous sessile capsules.

Photo: Doug Waylett (Canada).

Andes to Argentina. In the BI it occurs in Scotland and formerly England. The earliest English record is 1886, collected by the Revd. C.H. Binstead (1862–1941) from a bridge at Docker Garth railway station in Cumbria. Many years elapsed before the species was recorded again in England, maybe because few bryologists were looking out for it. In 1961, A. R. Perry and E. F. Warburg (1908–1966) collected it from a concrete road bridge across a railway line between Kendal and Grayrigg at an altitude of 150 m, probably the same locality where Binstead had gathered it 75 years previously. Six months later, a single cushion was collected by J. A. Paton and A. J. E. Smith from a railway bridge on the A685, between Kendal and Grayrigg. The plant has never been seen here since and other records from England have proved to be erroneous.

During the 1982 BBS Penrith meeting, J. Appleyard (1906–1989) and AJES collected what was initially thought to be *G. anodon* from Raven Craggs near Mungrisedale in the Lake District and, at the time, thought to be only the second known site in England. In 1995, the BBS returned to the Lakes for their spring meeting based at Ambleside. *En route* to the meeting H. L. K. Whitehouse (1917–2000) led a small party to re-find *G. anodon* at Raven Craggs. Small cushions of a plant looking like *G. anodon* were soon found on sunny south-facing crags of a disused slate quarry. Later, under the microscope, it became apparent that the plant was actually *Coscinodon cribrosus*. A Subsequent check of the original Appleyard-Smith collection confirmed it was also referable to *C. cribrosus*.



Grimmia anodon

Since the moss had not been seen in Scotland since 1871, it was pronounced extinct in Britain (Church *et al.*, 2001). Unknown at the time, however, it persisted at its infamous Scottish locality, Arthur's Seat in Edinburgh, but it was not until 2005 that D.G. Long confirmed that *G. anodon* was indeed alive and well in Scotland (Long, 2006).

It is likely that *G. anodon* is extinct in England as the last confirmed sighting was in 1961. It has always been very rare and only ever known from a single site in England. The reasons for its demise can only be guessed at, but it is not unreasonable to surmise that collecting may have compromised the survival of a plant that was already vulnerable by virtue of a small population on a man-made structure at the lower (probably suboptimal) limits of its altitudinal range. Ironically, whilst the history of the plant in England warns of the perils of over-collecting, it also nicely demonstrates the importance of having well curated herbarium vouchers for future studies. Confirmation of the occurrence of *G. anodon* in Scotland has resulted in transference from Extinct in Britain (Church *et al.*, 2001) to Critically Endangered on the revised British Red List.

M

GRIMMIALES

Grimmia elongata

Brown Grimmia

VU

BAP; NS

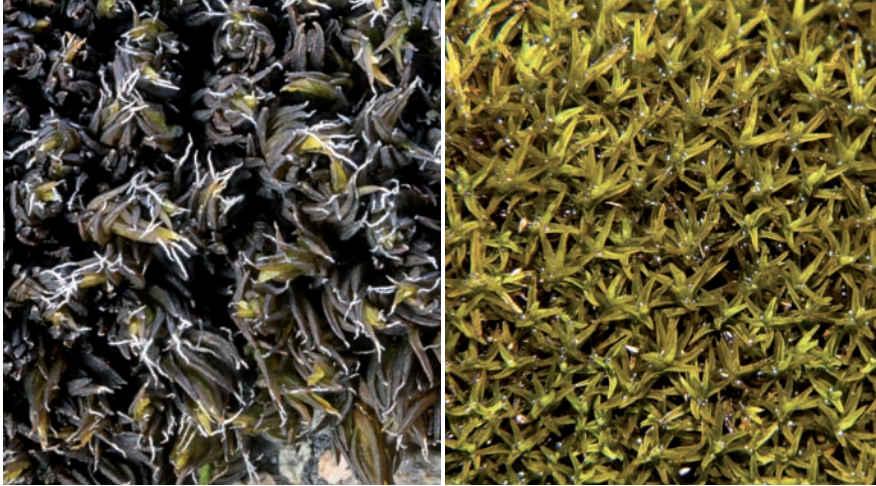
Upgraded

This species is a dull green to reddish-brown moss giving it a rather different appearance to other members of the genus (for derivation of the generic name, see *G. anodon* page 109). Shoots reach up to 20 mm tall, giving rise to small cushions or larger patches. The narrow tapering leaves are held close to the stem and are slightly twisted when dry, spreading when moist, with an inconspicuous silver hair-point. It is dioicous and sporophytes are unknown in Britain. Specialized asexual propagules are absent and it behaves as a colonist.

It is primarily a moss of acid, normally sunny rock, often slate, at high altitudes (500 m or more) where it is exposed to extreme environmental stress. It grows directly on slabs or in soil-filled crevices in both dry and damp situations, on block scree and occasionally on metalliferous rocks. It shares the rock with a range of saxicolous mosses including *Andreaea*, *Racomitrium* and other *Grimmia* species.

A member of the Circumpolar Arctic–montane element, it is widely distributed in the N and S Hemispheres. It is not threatened in Europe as a whole, where it is chiefly a plant of the Alpine belt in N and C Europe east to the Russian Urals, but is very rare farther south (Pyrenees) and rare in lowland countries such as Belgium and Britain. Elsewhere it occurs in N, S and C America, Hawaii, Asia (India, Nepal, China, Japan), S and E Africa. In the BI it is known from Scotland, Wales and England. The earliest English records date from around 1889, gathered by the Revd. C. H. Binstead (1862–1941) at Whiteside and Thornwaite in the Lake District.

The plant has been recorded in about a dozen stations on the high peaks just to the west of Keswick in Cumbria, and this area remains the British stronghold. It was last recorded from Westmorland, the southern adjacent vice-county, in 1966 by A. J. E. Smith in the Langdale Pikes area; it probably still persists but no one has looked (and therefore the distribution map should be interpreted with caution). A record from N Northumberland, by J. B. Duncan in 1931 from Bizzle Crag in the Cheviot Hills, has never been re-found. In England, since its discovery in 1889, the species has been recorded in every decade up to and including the



LEFT: When dry, the leaves of *Grimmia elongata* are twisted and black, contrasting with the short, silver hair-point. Photo: Des Callaghan. RIGHT: A rain shower transforms *Grimmia elongata* on Skiddaw slates in Cumbria. Photo: Robert Goodison.

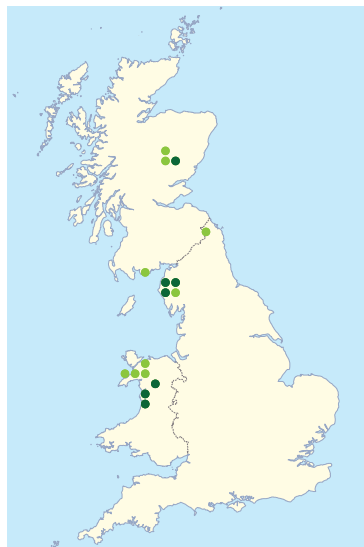


Hundreds of cushions of *Grimmia elongata* scattered across Gasgale Crags in Cumbria. Photo: Robert Goodison.

1960s, but not in the 1970s, only once in the 1980s and not at all in the 1990s. Then, in 2008, NE ecologist R. Goodison visited Lad Hows by Grasmoor and Gasgale Crags in Cumbria and discovered many hundreds of cushions growing on the Skiddaw Slates at 640 to 710 m above sea level; clearly it had been overlooked. English populations fall within two SSSIs: Buttermere Fells SSSI and Skiddaw Group SSSI, both of which are included in the Lake District High Fells SAC, which covers almost 27,000 ha.

There is as yet no published Action Plan (it was added to the UK BAP list in 2007). A search of the Westmorland and Northumberland localities and further survey in the Cumbrian Mountains should be a priority. Clearly it is very restricted in its British range

and a lack of sound baseline data makes trends difficult to determine. However, recent discoveries (particularly in Wales) have nudged the plant into the Nationally Scarce category (Preston, 2010). Gathering altitudinal data would also be worthwhile in order to assess any impacts of climate change that may act negatively on this Arctic–montane species; colonies at sub-optimal lower altitudes may disappear and many existing populations are more or less at their maximum upper limits in the Cumbrian Mountains. An occurrence at around 300 m at Screel Hill in Dumfries and Galloway has not been seen since A. C. Crundwell (1923–2000) reported it in 1957, possibly a victim of climate change. The revised British Red List classifies the plant as Vulnerable, upgraded from Near Threatened (Church *et al.*, 2001). The question is has there truly been a decline? A lack of baseline data and a need for further recording mean it is difficult to be certain.



Grimmia elongata

M

HYPNALES

Homomallium incurvatum

Incurved Feather-moss

VU

BAP; NR

Downgraded

This moss is a slender, green or light green mat-forming pleurocarp, with creeping shoots reaching 1–2 cm long and closely attached to the substrate. The leaves, about 1 mm long, taper from about mid-leaf to a narrow tip and are characteristically curved upwards and away from the substrate. It is monoicous and sporophytes are common; the capsule is distinctly curved (hence *incurvatum*) providing another field clue to its identity. Asexual propagules are unknown. The plant can be confused with *Hypnum resupinatum*, but this moss has erect or only slightly curved capsules, although identification should be confirmed microscopically. The plant behaves as a colonist.

It is a plant of small, basic stones at ground level on sparsely vegetated woodland floor, typically in humid, lightly shaded valley woodlands, occasionally on dry walls and piled stones and, exceptionally, on crag ledges. It avoids larger stones and boulders that are dominated by robust bryophytes. It does not tolerate deep shade, for example under Yew trees.

A member of the Eurasian Boreal–montane element, it is widespread and frequent in the mountainous limestone regions of Europe, extending north to Norway and south to Spain and Portugal. Elsewhere it is widespread in Asia from Turkey, the Caucasus, Iran, Siberia, Mongolia to Japan and the Russian Far East, and N America (very rare). It is inexplicably rare in the BI, known only from Scotland and England. The first British record was made on 13 July 1838 by the leading bryologist of the day W. Wilson (1799–1871), gathered at Helk's Wood, Ingleton in Yorkshire. The next day he journeyed some 20 miles north and found it by a roadside NW of Kendal in Westmorland. The naturalist explorer R. Spruce (1817–1893)



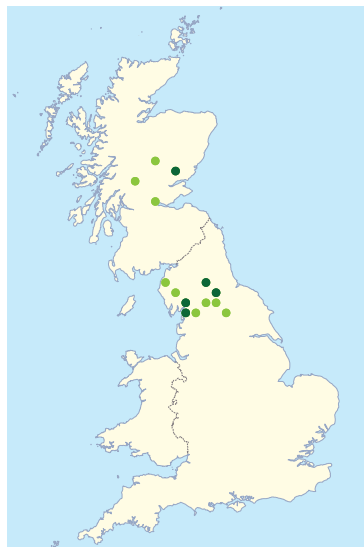
ABOVE: Small stones under a lightly wooded canopy are the typical niche of *Homomallium incurvatum*, photographed here at Whitcliffe Scar, North Yorkshire. Photo: Tom Blockeel. ABOVE RIGHT: An extreme close-up of the curved capsule of *Homomallium incurvatum*. Photo: Des Callaghan. RIGHT: *Homomallium incurvatum* showing the characteristic ascending leaves and shoot tips. Photo: Des Callaghan.

discovered it in 1843 at High Force on the River Tees in Durham, and reflected on how he might easily have overlooked it for *Amblystegium serpens*. Many records from the 1860s to 1915 can be attributed to four bryologists who evidently had the ‘search image’: J. M. Barnes (1814–1890), the Revd C. H. Binstead (1862–1941), G. Stabler (1839–1910) and R. Barnes (1851–1918). With the death of these men, the knowledge of the species also vanished and since 1950 it has been reported from only two sites in England: Ingleton, collected by A. R. Perry and others during a BBS meeting in 1969 (the site was subsequently destroyed by the extension of a car park) and at Gainford in Durham, collected by M. J. Wigginton in 1977. The historical distribution in England is therefore centred on three regions, around Kendal (Westmorland), Ingleton (NW Yorkshire) and Wensleydale, Swaledale and Teesdale in N Yorkshire and Durham. There are records from about 27 localities in England, either confirmed from herbarium specimens or otherwise considered reliable (but there is also some evidence that it was over-recorded in the past). The reasons for its apparent decline were unknown and there was unease for its survival.

Much of our recent understanding of the plant comes from the work of T. L. Blockeel under the UK BAP. In 2004, TLB was commissioned by *EN* to research the historical records of the species in England and to clarify the current status of the species; the outcome of the study was published in *Field Bryology* (Blockeel, 2007), the bulletin of the BBS Survey confirmed its presence at four of its historical sites, on the east bank of the River Kent between Sedgwick and Natland, and near Barrowfield below Scout Scar, both in Westmorland (Cumbria), and at Whitcliffe Scar in N Yorkshire and at High Force in Durham. The population at Whitcliffe Scar is particularly strong, occurring on numerous small stones in four distinct locations. Reports of the moss from elsewhere are expected to come to light; indeed D. A. Callaghan discovered a new population in 2010 at Blawith Hill, near Grange-Over-Sands, in Westmorland.

The plant had not declined catastrophically as feared earlier, but had been overlooked, partly because of its tendency to occur in rather ordinary niches and perhaps because few, if any, currently active bryologists had a good ‘feel’ for its habitat. Three of its extant sites are in SSSIs: Lower Swaledale Woods and Grasslands SSSI (Whitcliffe Scar), Upper Teesdale SSSI (High Force) and River Kent and Tributaries SSSI. The two latter sites are designated as SACs (Moor House-Upper Teesdale SAC and River Kent SAC respectively). The extant populations occur in, or at the edge of, deciduous woodland and conservation management requirements are minimal. Threats may include wall maintenance, excessive shading, and gross disturbance of stones on the woodland floor. There is little evidence that climate change is negatively impacting on it (Blockeel, 2007).

There are certainly more populations in N England waiting to be found and, coupled with the evidence that *H. incurvatum* may have been over-recorded in the past, its status has been downgraded from Critically Endangered (Church *et al.*, 2001) to Vulnerable on the revised British Red List.



Homomallium incurvatum

L

JUNGERMANNIALES

Jamesoniella undulifolia

Marsh Flapwort

VU

BAP; WCA; NR

Downgraded

This species is a bright green to reddish-brown leafy liverwort forming smooth mats with shoots to 5 cm long and 3–5 mm wide. The leaves are round with slightly wavy margins and are distant on the lower stem becoming more crowded above. It is dioicous, and although male and female plants are fairly frequent, sporophytes are very rare and do not reach maturity in Britain. Specialized asexual propagules are unknown. It is very similar to *Odontoschisma sphagni*, which occurs in the same habitat, but that species normally has colourless flagella (thread-like appendages) on the underside of the stem. *Jamesoniella* was named by R. Spruce (1817–1893) who thought that it resembled “miniature copies” of the South American fern genus *Jamesonia*. However, it has recently been transferred to the genus *Biantheridium* (Konstantinova & Vilnet, 2009) but this post-dates Hill *et al.*, 2008 and the more familiar former name is maintained in this book.

It grows in wet minerotrophic raised and valley bogs, in flushes and flushed grassland in open, unshaded niches. It is a pioneer colonist associated with early stages of the growth and decay cycle of *Sphagnum capillifolium* hummocks and grows with a range of other bryophytes, such as *S. papillosum*, *Aulacomnium palustre*, *Lophozia ventricosa*, *Barbilophozia kunzeana* and *Scapania paludicola*.

A member of the European Boreo–Arctic Montane element, it is listed as endangered in Europe (ECCB, 1995). It is considered globally rare (Laaka-Lindberg, Hedderson & Longton, 2000) and is on the IUCN World Red List of bryophytes. It has disappeared from many of its former sites in Europe and is on several national Red Lists. It is primarily a plant of N and C Europe and its stronghold appears to be the Massif Central in France (for distributional information see Hugonnot, 2012). Elsewhere it is known from Russia, Greenland and N America. In the BI it occurs in Wales (one recent site), Scotland (three sites) and England.

The plant was discovered in Britain by G. Stabler (1839–1910) from Barrowfield, Westmorland, in 1874. It persisted here for over 90 years, the last record made in 1965 by husband and wife R. D. Fitzgerald (1914–1990) and J. W. Fitzgerald (1908–1988). There are also old records from Sedburgh, Westmorland, in 1882 by G. Stabler and from Wiggpool Common, Worcestershire, in 1929–1931 by H. H. Knight (1862–1944). The earliest Cornish record, 1882, is attributable to W. Curnow (1809–1887) who collected it from Lower Ninnes Bog, north of Penzance. It has never been seen since in W Cornwall.

It was found in E Cornwall by J. A. Paton in the early 1960s, at Dozmary Pool and at Red Moor, and in 1980 from Witheybrook Marsh and Redhill Marsh. The formerly strong population at Redhill Marsh was lost when Colliford Lake (reservoir) was created in 1984, and the population on Red Moor has not been seen in recent years despite extensive searching. In 2003, survey under the UK BAP by D. T. Holyoak discovered a new albeit small population at Redmoor Marsh on Bodmin Moor. Fieldwork at Dozmary Pool SSSI in 2012 by D. A. Callaghan has shown it to be scattered but locally frequent over many tens of square metres in often moribund *Sphagnum capillifolium* hummocks. At Witheybrook Marsh, a Cornwall Nature Conservation Site, the liverwort is present as two strong colonies, and at Redmoor Marsh, a site with no formal protection, four discrete colonies were discovered in 2012, three of them strong.

In 2004, G. Rothero re-found a population in Westmorland on a *Sphagnum capillifolium* hummock on Helton Fell near Ullswater in the Lake District. In the same year, D. Wrench found it growing on *S. capillifolium* on the margins of a flush on Hopesay Hill, a NT property in the South Shropshire Hills. To turn up a new county record of a globally rare plant, and in an area that has been bryologically well-recorded, is quite remarkable. This was not the last

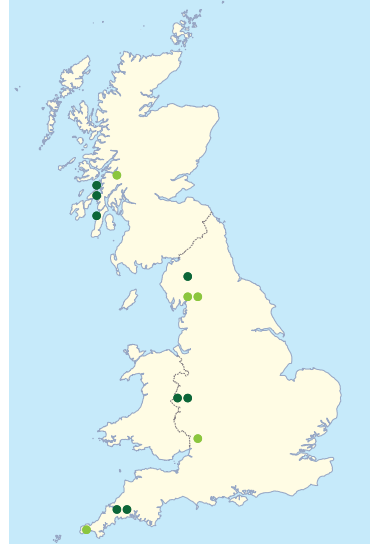


ABOVE: The rounded, wavy-edged leaves of *Jamesoniella undulifolia* are deceptively like the common leafy liverwort *Odontoschisma sphagni*. Photo: Des Callaghan. RIGHT: A shoot of *Jamesoniella undulifolia* pushing through the crimson *Sphagnum capillifolium*. Photo: David Holyoak.



surprise: in 2009, during a NT survey of flushes on the Long Mynd, Shropshire, M. Lawley found it in a flush at Nover's Hill, scattered over an area of several square metres (the largest population known so far in the county), and yet a third locality, comprising a few shoots, near Catbatch on the northernmost edge of Long Mynd; both sites are within the Long Mynd SSSI.

In the early 1990s *J. undulifolia* was thought to survive at just one site in Cornwall and one site in Scotland. Since 2000 the plant has been recorded from a total of seven localities in England; two are within an SSSI but none are in a SAC. It is fully protected under the WCA 1981. Threats include drainage of its habitat, flooding for reservoir creation, planting of conifers, inappropriate grazing regimes, eutrophication and pollution. The limitation in sexual reproduction and dispersal in *J. undulifolia* has implications for conservation management, and translocation may be an effective and justifiable tool to augment populations. It is currently held in non-axenic culture in the *ex situ* threatened bryophyte facility at RBGK; cryopreservation or axenic culture should be considered a priority.



Jamesoniella undulifolia

The apparent increase in localities is partly down to a better understanding of the plant's niche, gleaned not only by recent fieldwork in this country but also from studies in the Massif Central in France (Hugonnot, Bardat & Boudier, 2003). Given the apparent reversal of the decline evident towards the end of the 20th century, the plant has been downgraded from Endangered to Vulnerable on the revised British Red List.

L

JUNGERMANNIALES

Leiocolea rutheana

Norfolk Flapwort

EN

BAP; WCA; NR

No change

This olive-green, strongly aromatic, leafy liverwort forms smooth mats with unbranched shoots up to about 6 cm long and up to 5 mm wide. It has two ranks of overlapping, shallowly bi-lobed leaves with a margin that continues down the stem (decurrent), and a row of tiny but well-developed ciliate 'underleaves' on the underside of the stem. It is monoicous and sporophytes are occasional. Specialized asexual propagules are unknown and it behaves as a perennial stayer. Paton (1995) established that two varieties can be recognized in the British Isles, var. *laxa* (southern England only) and var. *rutheana* (England, Scotland and Ireland). They can be separated on leaf characters (lateral and underleaves) and nature of the rhizoids.

It is an obligate calcicole of wet calcareous fens and base-rich hillside flushes with tufa mounds. It is associated with a range of rich-fen plants, including Black Bog-rush and several bryophytes in particular *Campylium stellatum*, *Scorpidium cossinii* and *Palustriella falcata*.

The species is a Circumpolar Boreo–Arctic Montane plant, rare and relictual in most of Europe. Variety *rutheana* is known from about 15 European countries but is most frequent in Fennoscandia and northern Russia. Elsewhere it occurs in Siberia, N America and Greenland. Variety *laxa* is known only from England and Sweden (single locality). Variety *laxa*, first discovered in England in 1909 by W. H. Burrell (1865–1945) at Flordon Common in E Norfolk was new to science, but it was last seen there in 1927 by H. H. Knight (1862–1944) and W. E. Nicholson (1866–1945). In 1952, var. *laxa* was found at Swangey Fen in W Norfolk by G. H. Rocke, J. H. G. Peterken (1893–1973) and E. C. Wallace (1909–86) but has never been seen again. In 1955, E. L. Swann discovered var. *laxa* at Scarning Fen in W Norfolk, where it persists to this day. It was found in Berkshire by F. Rose (1921–2006) in 1983 but attempts to re-find it have been unsuccessful. Variety *rutheana* was more widespread in England: Buxton Heath, E. Norfolk, in 1951 by R. A. Boniface (1913–1985) but is now extinct; Holt Lowes in 1953 (also RAB), also extinct; Tarn Moor in Westmorland in 1982 by J. A. Paton, not seen since; and on Helton Fell, Westmorland by R. W. M. Corner in 1995, also vanished. Elsewhere, var. *rutheana* occurs in the Scottish Borders and in W Mayo, Ireland.

Known from four or five sites in the 1950–1960s (Holyoak, 2004), *L. rutheana* var. *laxa* is today known from one site in England: Potter and Scarning Fens SSSI/Norfolk Valley Fens SAC. The variety *rutheana* has possibly vanished from England. *L. rutheana* is fully protected under the WCA 1981 and was one of the first bryophytes to be added to the UK BAP in 1995. There have been many attempts to re-find this species at its historic English sites but habitat loss, lowering of water tables, drainage, lack of grazing and eutrophication have taken their toll. Scarning Fen, a Norfolk WT Nature Reserve, grazed by 2–4 cattle or ponies, has survived in better condition than most of the rich-fens of Norfolk and, until recently, *L. rutheana* occurred in pure mats or scattered shoots along some 100 m. Groundwater levels, monitored by automatic piezometer recording equipment on behalf of the EA, appear to be optimal for *L. rutheana*. However, a survey by C. R. Stevenson commissioned by NE in 2011, found only a single small colony.

The reason for this decline is unknown but may be due to overgrazing and nutrient enrichment; therefore stock has been withdrawn to buy time to investigate possible causes.



LEFT: *Leiocolea rutheana* variety *rutheana* – has it vanished from England? Photo: David Holyoak (Ireland). RIGHT: *Leiocolea rutheana* variety *laxa* at Scarning Fen, Norfolk showing the bilobed leaves. Photo: David Holyoak.

It may represent natural population fluctuation, or suitable sites are now too fragmented and small to enable metapopulation dynamics to operate effectively. Ironically, *L. rutheana* var. *laxa* is not a notified feature under the SAC designation; it is the fen community that is the main management objective for the site and currently it is judged to be in favourable condition. The conservation bodies are working to resolve the problem but the inflexible reporting mechanism may be driving condition assessments towards an 'ideal' fen community regardless of the fact that a globally rare plant is declining.

Under the UK BAP the reintroduction of *L. rutheana* var. *laxa* to at least four other sites where it once occurred is listed as a priority action. At some of the Norfolk fen sites, such as Buxton Heath and Holt Lowes, conservation management has reversed decades of neglect and open wet areas suitable for *L. rutheana* exist; the dilemma is that these two sites formerly supported variety *rutheana*. Variety *laxa* is by contrast globally threatened and currently restricted to Scarning Fen. Whether the former sites for this variety can be restored is uncertain but theoretically possible, and Flordon Common, the type locality of variety *laxa*, perhaps offers the best opportunity. Research in Sweden has demonstrated that it is possible to reintroduce a range of rich-fen bryophytes using gametophyte (the leafy plant) fragments to restored fen sites (Målson & Rydin, 2007). This variety is a compelling candidate for inclusion in the *ex situ* threatened bryophyte facility at RBGK, combined with experimental reintroduction trials. Molecular studies are also desirable to clarify the relationship of the two taxa currently considered at the varietal level.



Leiocolea rutheana

The species is classified as Endangered rather than Critically Endangered in the revised British Red List, since strong populations (var. *rutheana*) are known in Scotland. The IUCN Red Listing process is applicable to any taxonomic unit at or below the species level, but varieties and subspecies are disregarded in the compilation of the British Red List (Hodgetts, 2011). This decision reflects the inconsistent recording by field bryologists of taxonomic levels below species. Nevertheless, if *L. rutheana* var. *laxa* was assessed against IUCN guidelines, it would unequivocally qualify as Critically Endangered.

L

PORELLALES

Lejeunea mandonii

Atlantic Pouncewort

EN

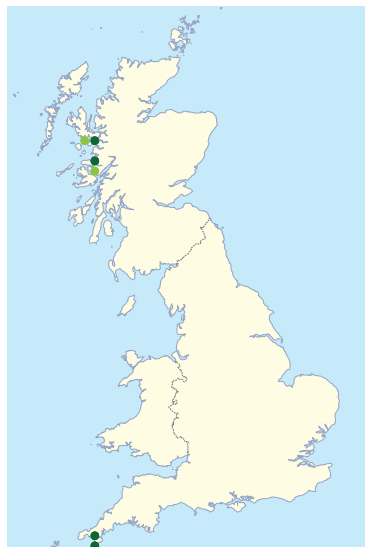
BAP; NR

No change

Lejeunea is a genus of small leafy liverworts named after the French physician and botanist A. L. S. Lejeune (1779–1858). They can be tricky to identify and *L. mandonii* is no exception. It forms pale to bright yellow-green smooth mats with shoots barely 1 cm long and about



The smooth, pale green mats of *Lejeunea mandonii* showing the narrowly rounded apex of the leaf lobes. Photo: Des Callaghan.



Lejeunea mandonii

0.5 mm wide. Its small size is a useful field character, as too is the shape of its leaves, which are rather narrowly rounded at their apex compared to other *Lejeunea* species. The smooth, round perianths are diagnostic but are difficult to detect in the field. It is monoicous and perianths are occasionally produced, but sporophytes are rare. Specialized asexual propagules are unknown and it behaves as a pioneer.

It typically grows as an epiphyte on other bryophytes that are weakened and moribund (as a result of growing in shade) including the mosses *Kindbergia praelongum*, *Isothecium myosuroides* and *Thamnobryum alopecurum* and the liverworts *Metzgeria furcata* and *Radula* spp. It shows a strong preference for rock overhangs where colonies are sheltered from direct rain, salt-spray and desiccating winds; it also grows in smaller quantities directly on the rock surfaces and on Ivy stems. The high humidity regime characteristic of its niche apparently provides sufficient moisture for growth. On the Lizard Peninsula in Cornwall the plant is confined to serpentine rock, which, although low in calcium, is rich in other bases particularly magnesium. In Scotland and Ireland it is known from wooded ravines, on trees, in coastal gullies and sea caves. It is an example of a species with a narrow geographical range that occurs in small populations but with low habitat specificity (Longton & Hedderson, 2000).

It is a globally rare liverwort, confined to markedly Atlantic areas and belongs to the Hyperoceanic Southern–temperate element. It is a European endemic known from Portugal, Spain, Madeira and the Canaries, and reaching the northern limit of its range in the BI. It is listed as rare in Europe (ECCB, 1995). In the BI it was first discovered in 1898 by the Scottish bryologist S.M. MacVicar (1857–1932) at Kinlochmoidart and was thought to be new to science and initially named *L. macvicari*. It was later synonymized with *L. mandonii* that had been collected earlier in Madeira by the French botanist G. Mandon (1799–1866), hence the name *mandonii* takes precedence. It persists in Scotland (three small populations) and Ireland (S Kerry and Leitrim). The first English record was made in 1923 by H. H. Knight

(1862–1944) in Bonython Plantation on the Lizard Peninsula in Cornwall. In the early 1930s it was recorded as an epiphyte on tree bark at Bonython (much of the woodland was later felled and re-planted with conifers) and also on nearby roadside serpentine outcrops (but not seen for over ten years). In 1935, it was found by HHK, J.B. Duncan (1869–1953) and W.E. Nicholson (1866–1945) on serpentine at Kynance Cove and in the Poltesco valley in 1965 by J.A. Paton. It still occurs in these three historic localities to this day, along with two additional populations found by D.T. Holyoak in 1997 close to the Poltesco site, near Gwendreath and Trevenwith. Thus, in England, the species is known only from the Lizard Peninsula.

It was one of the first bryophytes included on the UK BAP (1995) and considerable conservation effort has been directed to Cornish sites, including development of a monitoring protocol, marking of colonies, hand clearance of vegetation and tree felling. Despite annual fluctuations, in which weather appears to play a role, it is remarkably persistent. There is, however, a demonstrable decline, most notably in Bonython Plantation since the late 1990s, partly through the shading of serpentine outcrops by young Sycamore and conifers, a factor that is likely to get worse, but also the cyclical decay of the pleurocarpous mosses on which the species grows. In 2003, Plantlife International negotiated the removal of 31 Western Red Cedars but more needs to be done. In 1999, Bonython was estimated to support about 70% of the total population in England. DTH showed that *L. mandonii* declined from a total estimated population size of about 5,696 cm² in 1997 to 1,352 cm² in 2001; subsequent monitoring in 2009 and 2012 has confirmed a continuing decline. Threats elsewhere include excessive shading of serpentine outcrops by Ivy and other shrubs, risk from uncontrolled burning, and one population (Trevenwith) is at risk from *Rhododendron* growth.

The population at Bonython Plantation is at high risk; SSSI designation would significantly improve the fortunes of a globally rare plant. The other sites are within two SSIs (Poltesco, Trevenwith and Gwendreath are in Kennack to Coverack SSSI, and Kynance is in the West Lizard SSSI), both within The Lizard SAC. Other populations are within the Lizard NNR, on land owned by the NT and on private land. It is important that all populations are monitored annually or at an appropriate time period, fire-breaks created to minimize the risk of fire and *Rhododendron* control instigated where necessary. Material should be incorporated into the *ex situ* threatened bryophyte facility at RBGK, together with molecular analysis to clarify any genetic variation in populations. Given the restricted extent of occurrence and area of occupancy and the continuing observed decline, *L. mandonii* is classified as Endangered on the revised British Red List.

L

JUNGERMANNIALES

Lioclaena lanceolata

Long-leaved Flapwort

CR

BAP; NR

No change

Formerly known as *Jungermannia leiantha*, this is a small yellowish-green or reddish-brown prostrate leafy liverwort with shoots 10–25 mm long and up to about 3 mm wide. It has shortly oval to oblong leaves with a bluntly rounded apex, these being arranged on either side of the creeping stem, each leaf overlapped by the one behind. The defining character is the smooth cylindrical or club-shaped perianth that is abruptly flattened at its top with a short protuberance in the centre of a shallow circular depression. Fortunately this key feature



LEFT: A tuft of *Liochlaena lanceolata* clinging to a rock in a swift flowing stream.
RIGHT: A close-up of the closely overlapping leaves of shoots of *Liochlaena lanceolata*.

Photos: Michael Lüth (Norway).

is usually present as the species is monoicous and perianths and sporophytes are common. Tiny ovoid gemmae are present on the leaf margins and on the tips of modified attenuate shoots, but are apparently rare in Britain. Gemmae are very rare in the Jungermanniaceae; indeed they are known in only one other (non-British) species.

It is a plant of thin soil or humus overlying wet rocks, typically over sandstone but also on slates and shales, always where there is some base-rich influence. It occurs in lowland sheltered valleys, in flushes or on stones in humid wooded ravines. It is often mixed with other leafy liverworts such as *Calypogeia muelleriana*, *Cephalozia bicuspidata*, *Diplophyllum albicans* and *Lepidozia reptans*.

A member of the European Boreal–montane element, it is widespread and frequent in parts of N and C Europe, E to the Caucasus. Elsewhere it is known from N America. The earliest record appears to be from southern England on the Wealden sandstone; Edward Jenner (1803–1872), author of *Flora of Tunbridge Wells* (1845), collected it from Harrison's Rock in 1841. It was subsequently found at Ardingly rocks by the Sussex bryologist W.E. Nicholson (1866–1945) but there are no records later than 1910. It was recorded from Yorkshire by the great naturalist-explorer Richard Spruce (1817–1893) in 1942 on



Liochlaena lanceolata

wet rocks in Cronkley Gill near Whitby; in total it has been recorded from three sites in Yorkshire. In England *L. lanceolata* was last seen in 1966 at Twisleton Glen, Ingleton (Birks, 1966). The only place in the BI where the plant has been recorded since 1970 is in West Ross, Scotland. It is not uncommon on the continent but is inexplicably rare in Britain and the causes of its decline in England are difficult to understand.

There is currently no conservation action for this little known plant. Many of the sites where this species was recorded in the 19th century are known to be bryologically rich and are well worked, including the Wealden sandstone and Twisleton Glen; indeed the latter site is notable as the only known station for the Red Listed moss *Thamnobryum cataractarum* (page 178). Targeted survey of its historical sites, particularly in northern England, is a priority under the UK BAP. If it is re-found in England, consideration should be given to acquiring a small quantity of material for incorporation into the *ex situ* threatened bryophyte facility at RBGK. In view of its steep decline and fragmented range with no known extant populations in England, *L. lanceolata* is on the revised British Red List as Critically Endangered.

L

JUNGERMANNIALES

Lophozia capitata

Large-celled Flapwort

VU

BAP; NS

No change

This is a yellow-green, occasionally reddish-purple, creeping leafy liverwort with flattened shoots up to 20 mm long and 2 mm wide, often with ascending attenuate shoots tipped with a cluster of smooth green to purplish unicellular gemmae. The bi-lobed leaves are obliquely and alternately inserted on the succulent brittle stem. A combination of absent or rudimentary underleaves, large leaf cells (hence common name) and smooth gemmae separate this from related species. It is dioicous, and whilst male and female plants with perianths are not uncommon, sporophytes are rare. Asexual propagules in the form of gemmae enable the plant to rapidly establish colonies when conditions are optimal and it behaves as a pioneer colonist.

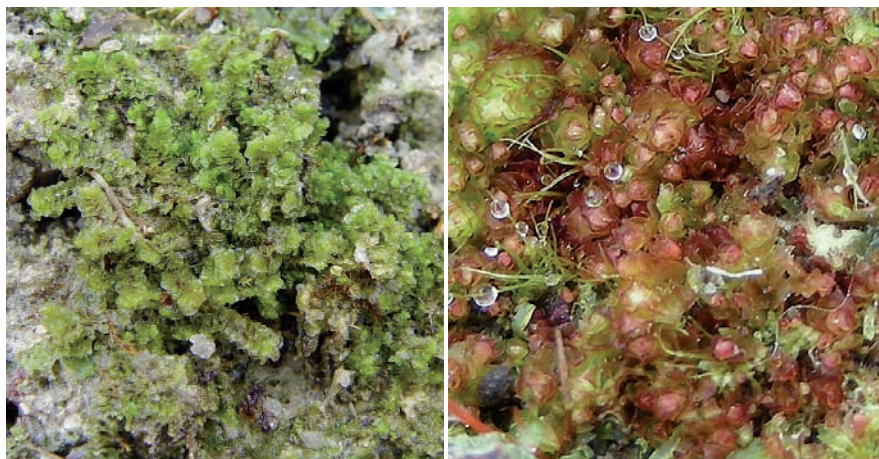
This is a plant of damp, nutrient poor, sandy, clayey or peaty soils in open or lightly shaded habitats. It occurs in disused sand pits and quarries, particularly where liable to flooding, sometimes forming extensive sheets but seldom persists for long. It also occurs in woodland rides and glades, less often on decaying bases of rushes and Purple Moor-grass and on peaty soil in bogs and on damp sandy ground amongst scattered heather on wet heath.

A member of the European Temperate element, it is rare and scattered through Europe excepting the southern countries and it tends to be associated with Tertiary or Quaternary sand deposits. It is a globally rare plant (Laaka-Lindberg, Hedderson & Longton, 2000) and elsewhere it is known from eastern N America. In the BI it occurs only in England, found in 1813 by the prominent botanist Sir W. J. Hooker (1785–1865), first Director of RBGK. He found the plant near Lyndhurst in the New Forest and published it new to science under *Jungermannia* in 1816. The specific epithet *capitata*, coined by Hooker, refers to the conspicuous densely crowded leaves at the apex of the female stem. It was collected from Cadnam Bog in 1813 and 1814 by the eminent geologist and Hooker's close friend C. Lyell (1797–1875), who spent his childhood in the New Forest. It was to be another 134 years before it was collected in England again.

In 1948, the distinguished hepaticologist E. W. Jones (1909–1992) gathered a puzzling liverwort from Chawley Brick Pit (Hurst Hill SSSI) near Oxford, which he tentatively put down to a large-celled form of *Lophozia excisa*. However, when he returned a year later, he realized the liverwort was *L. capitata* (Jones, 1950). Up to about 1951 it was very abundant on sand overlying clay on the floor of deep hollows in Chawley Brick Pit, but was long gone by 1985 (Jones, 1986). It was found at only one other Berkshire site, on recently abandoned gravel workings at Colemans Moor by E. V. Watson (1914–1999) in 1954, but was lost to development (Bates, 1995). Its lack of persistence, a few years at the most at any one site, is a reflection of its pioneer life-history strategy. It has been recorded from about 25 localities in ten vice-counties. It is thought to be extinct in two vice-counties (S Hants, last record 1914; N Essex, last record 1957) and there are no recent records from Berkshire, N Hants or Cheshire.

More recently it was found in Buckinghamshire by C. T. W. Tipper, in 2006 at Ivinghoe Common, and in Dorset where B. Edwards found it along a fire break in Wareham Forest in 2000; an unexpected and considerable westerly extension of its known range in England (Hill & Edwards, 2003). In Surrey it was known in three or four sites between the 1950s and 1970 but not seen since until the county recorder, H. W. Wallis, turned it up at three ‘new’ sites (Whitmoor Common, Wisley Heath and Wyke Common) in 2006–2009; it is possibly increasing in the county. In W Norfolk it has been recorded from six sites with post-2000 records from Bawsey Country Park and Leziate RSPB Reserve near King’s Lynn, largely due to sustained recording effort by C. R. Stevenson and the Norfolk Bryological Group.

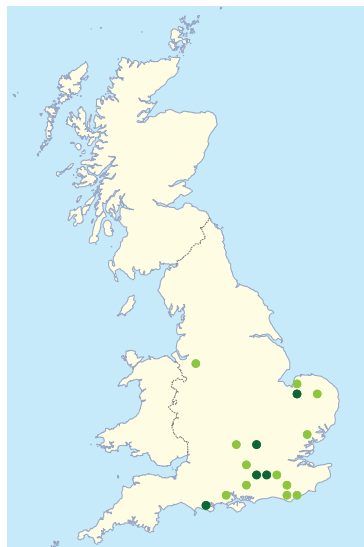
No specific conservation action is directed at this species and a UK BAP has yet to be published. A rare and transient species such as this presents challenges for conservation; ostensibly the most effective approach is habitat management on a landscape scale. Sexual reproduction is important for long-distance dispersal and although sporophytes are apparently rare in *L. capitata*, only a few spores are needed to establish metapopulations; its ability to colonize recently disturbed areas is evident in its occurrence on sandy and clayey soil in a heather regeneration plot at Ivinghoe Common. The main threats are loss of heathland and



LEFT: The leafy liverwort *Lophozia capitata* is a pioneer of open, sandy ground. Photo: Lucas Konecny (Czech Republic). RIGHT: The reddish-green shoots of *Lophozia capitata* revive after a shower of rain. Photo: Michael Lüth (The Netherlands).

the reclamation of pits and quarries, also neglect leading to loss of bare ground and competition from other plants. It is presently known to occur in four SSSIs and two SACs: Ashridge Common and Woods SSSI (within Chilterns Beechwoods SAC) in Buckinghamshire, and Ockham and Wisley Commons SSSI, Whitmoor Common SSSI and Ash to Brookwood Heaths SSSI (Thursley, Ash, Pirbright and Chobham SAC) in Surrey. Maintaining open wet heath with early successional communities in these SSSIs is fundamental to the plant's survival.

The species has been recorded from a total of 22 10km squares from 1950 and is thus listed as Nationally Scarce. Nevertheless there have been losses and gains and populations clearly fluctuate within a rather restricted range. It is therefore classified as Vulnerable on the revised British Red List.



Lophozia capitata

L

JUNGERMANNIALES

Lophozia herzogiana

Herzog's Notchwort

VU

NR

New addition

This plant is named after the great German bryologist and biogeographer T. Herzog (1880–1961). It is a small, green, leafy liverwort forming smooth mats with creeping shoots about 10 mm long and up to 1.8 mm wide. It has widely spaced to slightly overlapping bi-lobed leaves, each lobe triangular in shape, and tiny 'underleaves' on the underside of the stem. The characteristic field feature is the slender, erect shoot tips with reduced leaves terminating in conspicuous clusters of green gemmae (specialized asexual propagules). It is dioicous, and male and female plants and sporophytes are unknown in Britain. Its life-history is that of a pioneer colonist.

It is a plant of lowland acid heath and mire usually where there is sparse shade. It grows on damp litter of heather and birch, often mixed with algae and other bryophytes, and it also grows over *Sphagnum*. Associated species include *Calypogeia fissa*, *Campylopus flexuosus*, *Dicranum scoparium*, *Lophozia ventricosa* and *Odontoschisma denudatum*.

A member of the Suboceanic Temperate element, it shows a bipolar distribution (with no known intervening occurrences) and is very rare globally. It is known from New Zealand, Australia, England and Scotland. Whether this bipolar distribution is real or a result of humans moving it unintentionally from the north to south hemisphere or vice versa has been much discussed. It was first described new to science in 1962 by the eminent German botanist R. Grolle (1934–2004) based on material collected several times many years earlier, in 1929–1940, by the bryologist K. W. Allison (1894–1976), near Rotorua in North Island, New Zealand, on decaying tussocks, litter and rotting logs. It has not been collected from this area since, much of which is now pine plantation. The plant was then discovered in Australia in



Lophozia herzogiana, from Jean Paton's 1999 *Liverwort flora of the British Isles* (Reproduced by permission of Apollo Books and the author).



Lophozia herzogiana

1993, although not named until 2006, from the Tinderry Mountains of New South Wales near Canberra, on leaf-litter in open *Eucalyptus* woodland. Another as yet undetermined liverwort collected recently in South Island, New Zealand may also turn out to be *L. herzogiana*.

The first English record, found by A. C. Crundwell (1923–2000), was in 1986 on Woolmer Forest in Hampshire, growing amongst dense heather (Crundwell & Smith, 1989). It was supposed that either it had arrived here with troops from New Zealand during World War II or as a contaminant of imported wool shoddy used to fertilize land on a nearby estate. Both theories lacked solid evidence. Then in 2004 a surprising discovery was made; during a BBS field meeting R. Fisk found the plant growing on *Sphagnum contortum* on Mortlach Moss, a slightly base-rich flushed mire in N Aberdeenshire. This Scottish mire is relatively remote and pristine and this has led to the acceptance of *L. herzogiana* as a British native. There are certainly other bipolar bryophytes in the British flora, such as *Andreaea alpina*, *Anthelia juratzkana*, *Barbilophozia hatcheri*, *Buxbaumia aphylla* and *Ptilidium ciliare*, so the occurrence of *L. herzogiana* in the BI is not without precedent bryogeographically.

The current status of the plant in England is unclear. Woolmer Forest is designated as an SSSI and is also predominately MoD land; it is extensive and access is restricted. The original spot on Woolmer Forest where the plant grew was unwittingly destroyed by the excavation of a pond for Natterjack Toad, an all too familiar story of poor communication regarding locations of rare plants. Fortunately, several years later, in the late 1990s, another population was found in a different part of the site. Nonetheless recent searches by F. Rumsey have failed to re-find the population. It is not on the UK BAP as it was only recently considered to be native, but the priority should be to conduct a systematic search of the site and map the precise locations for use in future monitoring. Material should also be incorporated into the *ex situ* threatened bryophyte facility at RBGK. Furthermore, DNA studies may unravel some of the mysteries behind this inexplicably rare and disjunct liverwort. Given its restriction to two sites in Britain and the small populations, *L. herzogiana* is categorized as Vulnerable on the British Red List.

*Marsupella profunda***Western Rustwort**

VU

BAP; WCA; H&S; NR

No change

This plant is a small purplish-brown leafy liverwort in dense or loose turfs. Individual stems are about 5 mm long and less than 1 mm wide, but *en masse* form large patches. The tiny, weakly concave leaves are bi-lobed but it is the shape of the lobes that suggest *M. profunda* and separate it from similar species such as *M. sprucei*. In *M. profunda* the leaf lobes are rounded, sometimes broadly ovate or tongue-shaped (acute in *M. sprucei*). It is monoicous and sporophytes are common. Asexual propagules are lacking and it behaves as a colonist.

It grows on damp clay and on moist stones and boulders of crumbling mica granite (kaolinized) in disused and active china clay quarries. The substrates are typically acid, with a pH of 4.5–5.5. It occurs in sparse heathland, often with green filamentous algae, on flat ground and on inclined and vertical rock surfaces in sunny or sheltered positions. It is particularly characteristic of boulders in flooded disused pits where humidity is permanently high. It is often associated with *M. sprucei* and other pioneer liverworts, including *Diplophyllum albicans*, *Nardia scalaris* and *Solenostoma gracillimum*, and the mosses *Ditrichum heteromallum*, *Pogonatum aloides* and *P. urnigerum*.

A member of the Oceanic Southern-temperate element, it is a European endemic known only from England, Portugal (known from about eight sites post-1950 in the N), the Azores (on Santa Maria, rare) and Madeira (locally frequent). It is listed as vulnerable in Europe (ECCB, 1995) and is considered a globally rare liverwort (Laaka-Lindberg, Hedderson &



Dark brown cushions of *Marsupella profunda* dot boulders of crumbling mica granite in Cornwall.

Photo: Ron Porley. INSET: *Marsupella profunda* with its blunt, bilobed leaves can extensively colonize suitable ground. Photo: Des Callaghan.

Longton 2000). It was not recognized as a British plant until Jean Paton, in the late 1980s, was re-examining samples of *M. sprucei* and realized that Cornish material differed in the obtuse leaf lobes (Paton, 1990). Recent survey by D.T.Holyoak has shown it to be present in about 14 sites in E Cornwall, with one population alone estimated at over 20,000 cm². However, less than 0.5% occurs within the dedicated St Austell Clay Pits SSSI/SAC. A small population at Wheal Martyn SSSI, last seen in 2003, has vanished. In W Cornwall there are only two surviving populations, covering some 12,000 cm², both within the Lower Bostraze and Leswidden SSSI/SAC. A small population at Tregonning Hill SSSI/SAC, known since the 1960s, was last seen in 2003.

Threats include cultivation and tree planting, off-road motorbikes, and movement of spoil for road, track and path building. The principal threat, however, is vegetation succession and scrub encroachment; brambles, *Buddleja*, Grey Willow and *Rhododendron* are serious management issues. Under the UK BAP, there has been a sustained effort to remove scrub from the SSSI/SACs, and this continues to be vitally important in areas where new habitat is not being created. Glyphosate, a broad spectrum systemic herbicide has been trialled to assess its efficacy in slowing scrub development; it had no direct effect on *M. profunda* or other bryophytes but did impede other plants, at least temporarily, and hand clearance can be done at longer intervals. This biocide may eventually be withdrawn as there is increasing evidence of harmful effects on the environment and to humans; the EC has, however, delayed a re-assessment of the herbicide. Other conservation action has entailed translocations: small transplants (about 1 cm²) of *M. profunda* have been introduced into scarified ground with a cover of filamentous green algae, and entire granitic boulders supporting *M. profunda* moved to suitable sites. Both methods have been successful.

In addition to full protection under the WCA 1981, *M. profunda* is listed on Appendix I of the Bern Convention and is Britain's only plant Priority Species on Annex II of the EC H&S Directive. Considerable conservation resources from EN/NE, the china-clay industry and other bodies have been directed at this species. Under the EU Directive a site supporting an Annex II species must be designated as a SAC but here is the dilemma: *M. profunda* is currently present in two small SSSIs/SACs whilst the largest populations are *outside* designated sites. In essence, the conservation of this dynamic species cannot be achieved by small designated sites but requires a landscape scale strategy (Porley, Papp, Söderström & Hallingbäck, 2008). Survival depends on functioning metapopulations, where sub-populations come and go; the colonization and extinction rate must be in balance on approximately a 10–20 year time scale. As a cause of rarity in *M. profunda*, habitat availability is therefore more important than dispersal ability. In W Cornwall the china-clay industry has declined and no suitable habitat is being created (this could be imitated by explosives), whereas in E Cornwall, particularly around the St Austell area, there are tracts of potential



Marsupella profunda

ground and survey has confirmed that large populations do exist. SSSI/ SAC designation is not a panacea, and the way forward must be inclusive of the china-clay industry, nurturing a close partnership and providing best practice guidance (for example placing kaolinized boulders in flooded pits after a site has been worked).

This plant may not be at such high risk as was once feared when, by 1990, not one colony was known to survive. Yet if the long-term diagnosis is to remain positive a more innovative strategy is needed. Currently the species is classified as Vulnerable on the revised British Red List.

M

POTTIALES

Macromitrium tenerum

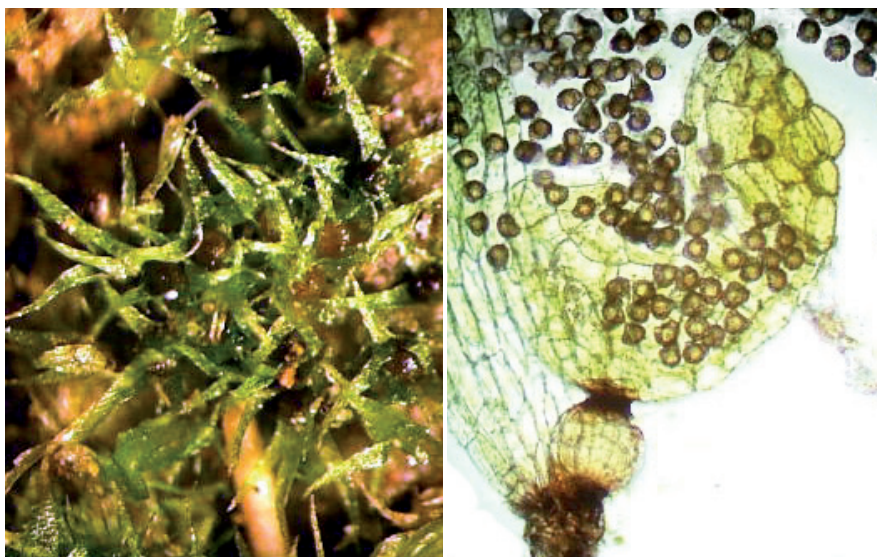
Millimetre Moss

EN

BAP; WCA; NR

Downgraded

This species, Britain's smallest moss, is scarcely 1 mm tall. The leafy shoots develop on persistent protonemata, the juvenile filamentous stage of a moss. The leaves are nerveless, entire or very slightly toothed near the apex and partially conceal a tiny sessile spherical capsule. The capsule is topped by a barely perceptible minute point and an even smaller calyptra or cap, hardly visible to the naked eye, sits atop the immature capsule (hence its name: *micro* = small, *mitrium* = a cap). It is monoicous, and sporophytes are frequent. It displays an episodic life-history strategy (During, 1997), adapted to niches that appear at irregular intervals, a strategy shared with a number of other mud-specialist bryophytes including the Red Listed moss *Physcomitrium eurystomum* (page 143). This contrasts with



LEFT: The long, tapering leaves conceal the capsules of the diminutive moss *Macromitrium tenerum* at its site in Sussex. RIGHT: Under the microscope a squashed capsule of *Macromitrium tenerum* bursts to release the spores. Photos: Howard Wallis.

the annual shuttle life-history strategy, where the niche is predictable and occurs every year.

It grows on non-calcareous mud as water levels fall; the 'draw-down' zone of ponds, lakes and reservoirs. Buried spores germinate on exposure to air and light as the mud dries and cracks. Its ephemeral life-history strategy is characterized by rapid establishment from a diaspore bank and a burst of sporophyte production at a prolific rate only to soon fade away.

A member of the Suboceanic Temperate element, it is very rare and sporadic in Europe and is listed as vulnerable (ECCB, 1995). It is the only species of the genus in Europe. There are records from Belgium, Czech Republic, France, Germany, Portugal, Sweden, Spain and The Netherlands. Elsewhere it is known from Africa (Zimbabwe), E and C Asia, western N America and New Zealand. The earliest English record, by Sussex chemist W. Mitten (1819–1906) is 1848, growing on mud around a pond near his home at Hurstpierpoint, Sussex. A few more records accumulated during the late 19th century, mostly from Kent, Surrey and Sussex, but by the 1950s they were beginning to diminish and the last record was by E. C. Wallace (1909–86) in 1968, from Hawkins Pond (St Leonard's Forest SSSI), W Sussex. It has been seen at about 16 localities in Britain since 1850, including an outlier in N Wales, but at only two sites post-2000: in N Devon in 2004 and in E Sussex in 2009/2011.



Micromitrium tenerum

The Devon plant, found by D. T. Holyoak, far from its centre of distribution, was at Roadford Reservoir east of Launceston, fruiting abundantly on damp, clayey mud with a pH of 7.1 amongst sparse grasses just above the water level. It was mixed with the moss *Pseudephemerum nitidum* and the invasive aquatic New Zealand Pigmyweed. The Sussex plant was found at Powdermill Reservoir (Howarth & Wallis, 2010) on exposed mud with *Riccia cavernosa* and *R. huebeneriana*; when the site was re-visited four days later the water level had been raised (for fishing) and only a small patch of *M. tenerum* was found. It was not seen in the summer of 2010 but was found again in 2011 following a period of very low water levels. These two localities illustrate the potential threats to the plant: the artificial manipulation of water levels and competition from alien invasive aquatic plants. Furthermore, the loss of ponds and other suitable water bodies and pollution have also taken their toll over the years.

The species has relatively large spores (to 30µm) and airborne dispersal is thought to be limited. Movement outside the SE England stronghold seems unlikely unless some other vector, possibly birds, is involved. Understanding population persistence and periodicity of occurrence is fundamental to its conservation. It is not recorded every year, as its occurrence depends on weather conditions and the extent of water draw-down. At Pond Lye, Hurstpierpoint in W Sussex it was seen in five years out of eight, at Hawkins Pond in W Sussex in four years out of 19, and at Hedgecourt Pond in Surrey in three years out of 25. Herbarium specimens are not collected in a systematic way and sampling bias can arise, yet the data do suggest that the spores can remain dormant in mud for many years. Remarkably,

in NW Germany the species was shown to be present in the soil of several oligotrophic ponds in a region where it had never been found above ground (Schmidt and Kohn, 1993).

Neither of the two post-2000 sites for this plant is designated, although the moss is fully protected under the WCA 1981. It is important to annually monitor water levels and the presence/absence of *M. tenerum* to understand its population dynamics. Other than being held in axenic culture in the *ex situ* threatened bryophyte facility at RBGK, there is no specific conservation action aimed at this plant and a UK BAP is yet to be published. Survey is problematic given its sporadic and unpredictable occurrence; low rainfall years, which may occur with greater frequency if climate change predictions are fulfilled, provide an opportunity to search for ephemeral colonists of ponds and reservoir margins. The discovery of two new localities in England has resulted in its status being downgraded from Critically Endangered (Church *et al.*, 2001) to Endangered on the revised British Red List, but it remains at high risk due to the small number of sites and the extreme fluctuations from year to year.

M

BRYALES

Mielichhoferia elongata

Elongate Copper-moss

VU	NR
No change	

This species, named in honour of the Austrian bryologist M. Mielichhofer (1772–1847) who discovered the genus in the Austrian Alps, is a distinctive pale green to glaucous moss forming dense velvety turfs with shoots to 15 mm tall. The oval, slightly glossy, overlapping leaves have a thick nerve ending below the finely toothed acute leaf tip. It is dioicous and sporophytes have never been found in England. Deciduous shoots serve as asexual propagules and it behaves as a stress tolerant perennial. In the past it has been treated as a synonym or variety of *M. mielichhoferiana*, but molecular work has demonstrated they are distinct and thus two species are currently recognized in Europe; indeed in the field they bear little resemblance to each other.

It is one of the so-called ‘copper-mosses’ or metalophytes, occurring on strongly acid lithosols (soils consisting of un-weathered or partly weathered rock particles) containing high concentrations of both heavy metal sulphides and rare earth elements. In England *M. elongata* grows on unstable steep Liassic shale with a predominately N to NE aspect, in cool humid deeply incised gullies with little or no direct sunlight and with a constant seepage of water. No other plants coexist in this extreme micro-environment. The bryophyte cell wall is very efficient at immobilizing heavy metal ions and is the main mechanism of heavy metal tolerance (Tyler, 1990).

It is a member of the Suboceanic Boreal–montane element, and like other ‘copper mosses’ it has a wide and highly disjunct geographic range and is nowhere common. In Europe it is considered insufficiently known (ECCB, 1995) and is reported from Spain, France, Italy, Switzerland, Austria, Norway, Sweden and Svalbard. Elsewhere it occurs in Siberia, Tajikistan and is scattered in N America (most notably in the Rocky Mountains of Colorado, where it occurs on mine spoil). In the BI it occurs in Scotland (first record 1830) and England. The first English record, in 1861, is attributable to the botanist and lichenologist W. Mudd (1830–1879) who gathered it in the Cleveland Hills at Ingleby Greenhow, on the North



LEFT: A rain drop trickles over a turf of water-repellent *Mieliichhoferia elongata*. Photo: John Game (California). RIGHT: The blue-green shoots of *Mieliichhoferia elongata* in splendid close-up. Photo: Des Callaghan.

York Moors at an altitude of about 275 m. One or two other botanists recorded it from here around the same period, including J. Backhouse (1825–1890) and in 1910 by R. Barnes (1851–1918) and L. J. Cocks (1859–1921/2).

There were no further records until 1954, when J. Appleyard (1906–1989) ‘rediscovered’ *M. elongata* at its classic locality. Several bryologists then came to see it during the 1950s and 1960s including C. D. Pigott who published a short note (Pigott, 1958). The BBS held their summer meeting at Northallerton in 1967 and journeyed to Ingleby Greenhow; they duly found it in two places, growing on crumbling Lias in steep gullies. In the 1960s P. D. Coker investigated the chemical composition of the English and Scottish lithosol residues in herbarium packets by spectrophotometric analysis; they differed considerably in the relative proportions of heavy metals and their sulphides (Coker, 1971).

Another gap in records ensued until the BBS returned in 1997. J. M. Blackburn, the former BBS County Recorder, soon located the plant but those in the party who had seen it in the late 1950s had the impression that it had greatly declined. JMB reports, however, that it was still reasonably abundant at a spot known as Botton Head, and in 1999 at least ten colonies were seen on shale banks at Grain Beck some 2 km NE of the main population. The precipitous shale slopes on which it grows are unstable, but it also grows



Mieliichhoferia elongata

on adjacent more stable banks from which it appears to spread. The main population lies within Botton Head SSSI (notified for its geological interest) and adjacent populations are within North York Moors SSSI/SAC, all wholly within the North York Moors National Park. The surrounding land is managed for grouse shooting but this has little impact on *M. elongata*.

The rarity of *M. elongata* is in part due to its highly restricted and narrow niche – pyritic rocks with an extremely low pH caused by oxidation of sulphides by sulphur bacteria. Dispersal is also probably a limiting factor and is largely by deciduous shoots and fragmentation of cushions. It is not on the UK BAP and there is no specific conservation action. It is classified as Vulnerable on the revised British Red List on the basis that it is known from just four localities in Britain.

L

JUNGERMANNIALES

Nardia insecta

Bug Flapwort

VU

NR

Upgraded

This is a small, yellowish-green or pale to greyish-green, leafy liverwort with creeping shoots about 10 mm long to 1.5 mm wide. It forms thin mats with the tips of individual shoots ascending and when fresh appears slightly fleshy and brittle. The broadly rounded overlapping leaves are arranged in two rows along the stem and are consistently bi-lobed to about one third of the leaf, each lobe roughly triangular in shape. It has tiny but distinct ‘underleaves’ on the underside of the stem. It superficially resembles several other leafy liverworts so microscopic examination is required. It is monoicous and usually fertile with perianths concealed within the upper leaves. Only immature sporophytes have been observed in British material. Specialized asexual propagules are absent. The species is said to behave as a long-lived shuttle.

It is a species of moist acid (pH 4-6) sandy or humic soil on moderately steep banks in the flood-zone of a stream at 300 m altitude. Whilst it tolerates some shading from sub-shrubs and grasses, it mostly grows on bare patches of ground with other common bryophytes such as *Cephalozia bicuspidata*, *Dicranella heteromalla*, *Pellia epiphylla* and *Polytrichum commune*.

A member of the European Boreal–montane element, it is discontinuously circumpolar, scattered and rather uncommon in Europe, mostly in the mountains (Alps, Carpathian, Tatra), but also known from lower altitudes in Fennoscandia, Belgium (Ardennes), The Netherlands, France, Estonia, N Russia and Iceland. Elsewhere it is known in N America. It was published new to Britain in 1995, discovered by chance as a result of a herbarium study of the similar *N. geoscyphus* (Blackstock, 1995). It was collected by J. W. Fitzgerald (1908–1988), E. M. Lobley (1902–1977) and A. R. Perry in 1964 from the banks of Chirdon Burn at Seven Linns in S Northumberland, but its true identity was not appreciated at the time. T. H. Blackstock visited the site in 1993 and *N. insecta* was re-found on the north banks of Chirdon Burn in some abundance in three discrete locations.

The plant is known from one site in NE England, from a fairly ordinary upland burn in a sandstone gorge at an altitude of 300 m. Why it is so rare is a conundrum and although it was expected to turn up on other moorland burns, so far it has not. The site receives no formal protection and occurs in Wark Forest, the southern part of FC owned Kielder



LEFT: *Nardia insecta* nestled amongst a forest of *Polytrichum commune* by Chirdon Burn, Northumberland. RIGHT: The characteristic fleshy, brittle shoots of *Nardia insecta*.

Photos: Richard Lansdown.

Forest. Planting of conifers, predominately Sitka Spruce, Norway Spruce and Lodgepole Pine, began in the 1920s and Kielder is the largest planted forest in Europe. Conifers were established in the upper catchment of the burn in the 1950s but a narrow streamside zone, 5–20 m in width, was left unplanted and it is here the plant resides. The planting of conifers so close may have consequences for its survival in terms of altering the hydrology of the stream catchment area. It was also suggested that the liverwort may be vulnerable to overgrowth by surrounding vegetation that would otherwise have been kept in check by livestock grazing prior to the land-use change (Blackstock, 1995).

In June 2006, R. V. Lansdown and N. G. Hodgetts visited the site and found two colonies, although deep water in the burn made access rather hazardous. RVL, with FC support, returned to Chirdon Burn in January 2011 with the aim of accurately mapping the colonies, but despite intensive searching the liverwort could not be seen. The area where the plant had been noted in 2006 had evidently been entirely scoured by flood water leaving virtually nothing but bare ground. It is not clear whether this event is normal and to what extent the plant is adapted to such conditions. As the plant was previously listed as Data Deficient (Church *et al.*, 2001) it was not included on the latest UK BAP list and hence lacks an Action Plan. Nevertheless, in light of the



Nardia insecta

possibility that it may be in decline, high priority should be given to re-surveying the site in the late summer, when water levels are at their lowest, to gain a better understanding of the conservation needs of this liverwort. Given that *N. insecta* is restricted to a single site in England, it is classified as Vulnerable on the revised British Red List.

M

BRYALES

Orthodontium gracile

Slender Thread-moss

VU

BAP; NR

No change

This is a yellow-green, slender-leaved moss forming turfs or scattered shoots usually less than 10 mm tall. In moist conditions the narrow leaves point in one direction (secund) but when dry are characteristically wispy. It is monoicous and sporophytes are common. The capsule is a pale tan colour and is smooth when dry and empty. It grows with the superficially similar alien *O. lineare* but that species tends to have slightly stiffer, wider leaves and the mature capsule is reddish-brown and usually ribbed when dry. Specialized asexual propagules are present in the form of protonemal gemmae and it behaves as a colonist.

It grows in wooded areas on lowland sedimentary acid outcrops, on porous sandstones and gritstones, usually in niches that are humid and lightly shaded by a tree canopy or on a sheltered aspect, on vertical surfaces or on ledges, often following lines of moisture. More rarely it grows on rotten wood including standing trees and in the past it has been recorded on peaty or sandy soils around tree bases. Other associated bryophytes include *Campylopus flexuosus*, *Cephalozia catenulata*, *Dicranella heteromalla*, *Lepidozia reptans* and *Tetraphis pellucida*.

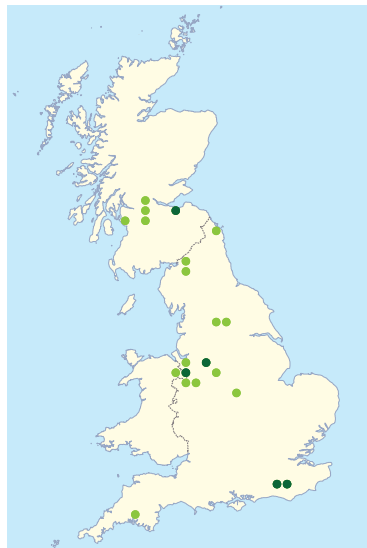
It is a member of the Oceanic Southern-temperate element, and in Europe *O. gracile* is known only from France (last record 1953 in Fontainebleau, Seine et Marne, and probably extinct) and Madeira (very rare), and is considered endangered in Europe (ECCB, 1995). Elsewhere it is widespread in the tropics and subtropics, on *Eucalyptus* in Australia, and in coastal redwood forests of Pacific N America. In the BI it is known from Ireland (first record 1993 but not re-found), Scotland (first record 1861), Wales (1882 but probably extinct) and England. The first English record was by made the leading bryologist of the day W. Wilson



LEFT: The sandstone rocks at Alderley Edge, Cheshire, provide the habitat of *Orthodontium gracile* together with its alien cousin *Orthodontium lineare*. Photo: Ron Porley. RIGHT: The Sussex Wealden sandstone is the stronghold for *Orthodontium gracile* in England, seen here at Eridge Rocks. Photo: Ron Porley.



A sheet of wispy-leaved *Orthodontium gracile* showing the characteristic smooth, light-brown capsules intermixed with *Tetraphis pellucida* and small leafy liverworts. Photo: Ron Porley.



Orthodontium gracile

(1799–1871), in 1833, from the Frodsham Hills in Cheshire. He left home on 25th March with the intention of collecting the moss *Schistostega pennata* but instead collected an unfamiliar moss growing on rocks at the foot of Helsby Hill; it turned out to be *O. gracile* and was new to science. It has been recorded from nine English vice-counties, mostly during the mid- to late-1800s. By the end of the 20th century records declined sharply, possibly because bryologists lacked the ‘search image’ of the older generation and confusion with the expanding *O. lineare*. However, targeted survey in 1999/2000 under the UK BAP confirmed that *O. gracile* lingered in E Sussex, Cheshire and mid-West Yorkshire, albeit in small quantity (Porley & Matcham, 2003). It also survives in Midlothian and possibly elsewhere in Scotland.

The British stronghold is the Weald in E Sussex, where it was formerly known from at least nine sites. The earliest collection was by W. Wilson, in 1845 from Eridge Rocks, a site designated as an SSSI and where it survives to this day. There are only two other extant localities on the Wealden Sandstone; one near West Hoathly, where it has been known since 1860. and at Paddockhurst Park, known since 1972. Both sites are within the Wakehurst and Chiddingfold Woods SSSI. In Cheshire it survives in three spots, on a damp wall built from sandstone just outside Peckforton Woods SSSI, a small colony on the northern flank of Bulkeley Hill and at Alderley Edge SSSI, confined to a small area known as Castle Rock. In mid-West Yorkshire the plant is known from Strid Wood SSSI, found by naturalist-explorer Richard Spruce (1817–1893) in 1841. The last confirmed sighting of the species here was in 1999, on three or four gritstone outcrops and on a rotting standing oak tree. This is probably the same oak that W. H. Burrell (1965–1945) gathered it from in 1938 and in 1940. A visit by the BBS in April 2011 reported that the tree had fallen and, somewhat ominously, *O. gracile* was not seen anywhere in Strid Wood.

The plant has always been precarious in Britain; a herbarium voucher dated 1846 from Alderley Edge is annotated “*nearly extinct*”, and Wilson described it as “*very rare*” when he

visited Strid Wood in 1850. It was last seen in S Devon in 1959, Staffordshire in 1897, Shropshire in 1892, Leicestershire in 1946, N Northumberland in 1926 and Cumberland in 1968. It seems to be sensitive to changes in the microclimate, but over-collecting may have contributed to its demise given the copious material in many herbarium packets; furthermore such collections suggest a former abundance not seen today. The protonemata is perennial, and thrives under conditions suboptimal for gametophyte (the leafy plant) maturation or sporophyte development (Duckett, Goode & Matcham, 2001), which may explain its persistence. The protonemal gemmae are relatively thin-walled and may possibly only play a role in local dispersal. The suggestion that *O. gracile* was ousted by *O. lineare* may only be part of the story. The native species was in decline before the introduced species took hold in Britain (first recorded in 1910); *O. lineare* may simply be exploiting unoccupied niches.

The species is held in the *ex situ* threatened bryophyte facility at RBGK in both cryopreservation and axenic culture. During the 1999/2000 census most populations were marked in the field with microchips to enable precise relocation and re-survey is long overdue. Currently *O. gracile* is classified as Vulnerable on the revised British Red List.

M

ORTHOTRICHALES

Orthotrichum pallens

Pale Bristle-moss

EN

BAP; NR

No change

This small, dark green moss forms cushions 5–10 mm tall. The leaves, hardly altered when dry, have recurved margins and a nerve that ends just below the blunt leaf apex. It is monoicous and sporophytes are common. The pale (hence *pallens*) shiny ribbed calyptra (the cap atop the capsule) has an orange tip that provides a good field character in early summer. *Orthotrichum* means ‘straight hair’ and refers to the erect sparse hairs on the



LEFT: A tuft of *Orthotrichum pallens* on bark with ribbed capsules releasing their spores.

RIGHT: The pale calyptra with its orange tip is a good field character for *Orthotrichum pallens*.

Photos: Michael Lüth (Germany).

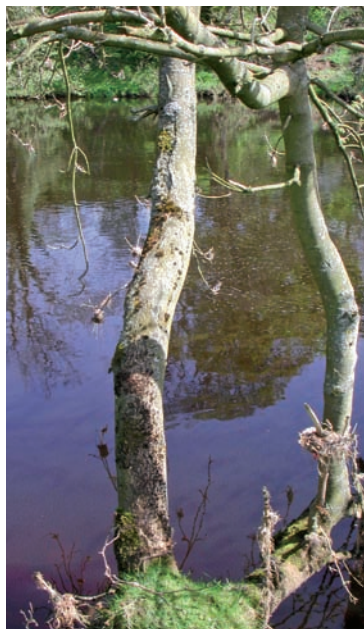
calyptra, but in some species, including *O. pallens*, hairs are absent. Specialized asexual propagules are unknown in Britain. It behaves as a pioneer colonist.

It is an epiphyte on rather moribund twigs and thin branches but also on boughs and on trunks, usually on base-rich bark, often along riverbanks or in wet willow and Alder scrub or in open sites such as woodland edge. Host trees include Alder, Ash, Elder, Hazel, Sycamore, willow and Wych Elm and, rarely, Holly. It is a poor competitor but it is usually associated with other *Orthotrichum* species and a range of common epiphytic bryophytes. At one site it occurs with the Red Listed *O. pumilum* (page 139).

A member of the European Boreo-temperate element, it is widely scattered throughout Europe, with its core range in N and C Europe. Elsewhere it occurs in N Africa, Turkey, Greenland and N and C America. In the BI it is known from Ireland, Scotland, Wales (discovered in 2011) and England. The first British record was made by naturalist-explorer R. Spruce (1817–1893) who collected it at Clifton Ings near York in 1842. Several more Yorkshire records followed but it slowly declined and in 1934 the renowned Victorian bryologist H. N. Dixon (1861–1944) was to be one of the last people to see the plant in the county, and indeed in England, for many years to come.

Orthotrichum are particularly sensitive to pollution, especially to SO₂ (Bates & Preston, 2011; Porley & Hodgetts, 2005) and *O. pallens* is no exception. The species is difficult to separate from similar species such as *O. stramineum* and the Red Listed *O. pumilum*; it was not until T. L. Blockeel revised a number of collections for the 1998 Census Catalogue that a better understanding, albeit still imperfect, of its distribution emerged. Several older records were discarded as erroneous and it seemed that the plant was extinct in England, the last reliable record being that of Dixon's 1934 collection.

The discovery in 1999 and 2000 of several colonies of *O. pallens* by local bryologist T. S. Wharton in Weardale, new to Co. Durham, the first sighting of the plant in England for 65 years, prompted targeted survey under the UK BAP. As a result it is now known from at least seven sites in Weardale comprising 11 sub-populations (Hodgetts, 2003). At some sites the plant occurs as single, or just a few, tiny cushions on trees but four sites in particular stand out: the River Wear at Wolsingham, on dozens of trees in riverine swamp woodland on the north bank of River Wear; Green Bank on several hedgerow, roadside and riverine woodland trees; near Holebeck House, several patches on a horizontal bough of a partially fallen Alder and Harperley Hall, on a riverside Ash mixed with the Red Listed *O. pumilum*. In recognition of the importance of Weardale for *O. pallens*, a Local BAP was published (the Durham Biodiversity Action Plan) promulgating sensitive riverside management by



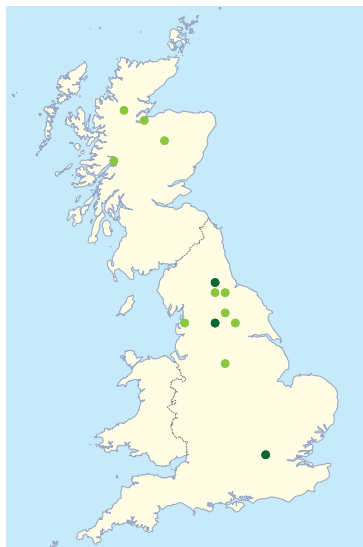
Tufts of *Orthotrichum pallens* on an Ash by the River Wharfe at Addingham in North Yorkshire, known for at least 150 years from the area.

Photo: Nick Hodgetts.

landowners and managers and the need to carry out further survey.

In 2005, N.G.Hodgetts found *O. pallens* on an Ash tree on the west bank of the River Wharfe at Addingham in NW Yorkshire; it was first found at Addingham in 1855 and again in 1858 by B.Carrington (1827–1893). Since it is thought individual cushions are short-lived (Hodgetts, 2003) it seems improbable that the plant has tenaciously hung on here for 150 years; more likely it is a recent arrival. Further records were anticipated as populations recovered and spread out, and in 2007 it appeared in Hertfordshire for the first time, found by BBS recorder C. T. W. Tipper on a willow bough in wet scrub by the River Gade and Grand Union Canal in Cassiobury Park, Watford.

Orthotrichum pallens is not known to occur on an SSSI or other designated site. Epiphytes tend to be under-represented on designated sites as they can, and do, turn up on trees in the most unlikely situations. Specific threats to *O. pallens* include felling (often on dubious health and safety grounds) of host trees, insensitive management of hedgerows and riverine woodland, and the impacts of road maintenance. It may also be vulnerable to agricultural spray-drift and possibly from eutrophication and nitrogen deposition, although observations suggest that it may be tolerant of nutrient input providing competitors are absent. Site condition should be monitored at least once every three years, the population at least once in every six years and the outcome used to inform management. Given its pioneer colonist life-history, *ex situ* conservation is arguably not a high priority, particularly if *O. pallens* continues to spread, although this should be kept under review. In view of its small area of occupancy and low number of sub-populations and the vulnerability of its habitat to inappropriate management *O. pallens* is classified as Endangered on the revised British Red List.



Orthotrichum pallens

M

ORTHOTRICHALES

Orthotrichum pumilum

Dwarf Bristle-moss

EN

BAP; NR

Downgraded

This is a small (*pumilum* = dwarf), pale green moss forming compact cushions to about 5 mm tall. The leaves, little altered when dry, have recurved leaf margins and a nerve that ends just below the rather pointed leaf apex. It is monoicous and sporophytes are common. It shares with the Red Listed *O. pallens* (page 137) a hairless calyptra but unlike that species *O. pumilum* has a smooth calyptra rather than a ribbed one. Specialized asexual propagules in the form of protonematal gemmae are produced both *in vitro* and in the wild (foliar gemmae are reported on plants in Europe but have not been seen in Britain). It behaves as a colonist, colonizing unpredictable but relatively long lasting niches.



Orthotrichum pumilum is a rare epiphyte but its range may be expanding. Photo: Štěpán Koval (Czech Republic).



Orthotrichum pumilum

It is an epiphyte on usually base-rich bark of various trees including Ash, elms, Sweet Chestnut and willow. A plant of the lowlands, it grows on trunks and boughs in sunny positions such as along rivers and woodland edge. It is a poor competitor but seems to tolerate marginally elevated nutrient levels. In Europe it occurs in cities and increasingly on mortared walls. It is associated with a range of common epiphytes and other *Orthotrichum* and at one site with *O. pallens* (see page 137).

A member of the European Temperate element, it is widely distributed throughout Europe at lower altitudes from Scandinavia to the Iberian Peninsula and E to the Balkan Peninsula. Elsewhere it is known from Macaronesia, N and S Africa, Asia and N America. In the BI it is known from Scotland, Wales (discovered in 2011) and England. The earliest British record is 1843, collected by the naturalist-explorer R. Spruce (1817–1893) from an Ash tree near York. The next collection, over 40 years later, was made by the leading Victorian bryologist H.N. Dixon (1861–1944), from Cransley, Northamptonshire in 1885 but it was not seen again in England during that century. It turned up in E Norfolk in 1907 and from Brandon, W Suffolk in 1911, found by W.H. Burrell (1865–1945). Another lengthy gap was to follow before the next confirmed record at the beginning of the 21st century.

This plant is very close to the Red Listed *O. pallens* and some older collections may require revision. Both taxa are in the process of having their DNA sequenced (barcoded) at RBGE and the results are eagerly awaited. There is also uncertainty over its relationship with another very closely related taxon, *O. shimperi*. Although some authorities regard this species as synonymous with *O. pumilum*, it does seem that the *shimperi* form is distinct and it is particularly characteristic of the Mediterranean region. Further study of the *shimperi* form is clearly needed, but at least the distribution and status of the *O. pumilum* aggregate is now much better understood. The decline in England is related to SO₂ pollution, which peaked in the 1960s–1970s, causing a widespread decline of many epiphytes. Their subsequent recovery in the wake of cleaner air has been remarkable and well documented

(Bates & Preston, 2011; Porley & Hodgetts, 2005). In May 2000 *O. pumilum* turned up in Co. Durham after an absence of nearly 90 years. It was collected by local bryologists T. & J. Wharton from the trunk of an Ash tree by the River Wear near Low Tapperley. It was the first time the plant had been recorded in Co. Durham, and is now known from two Ash trees in close proximity, on one of which it is mixed with the Red Listed *O. pallens*. A further sign of a recovery came in 2010; it was found by BBS recorder C. T. W. Tipper on an Ash tree at the edge of a plantation at Kensworth Quarry near Luton, Bedfordshire and in 2012 C. R. Stevenson turned it up in a Norfolk orchard (records not mapped). This moss has always been rare in England and has been recorded from a total of six vice-counties; post-2000 it is known from three and more may follow.

There is currently no specific conservation action aimed at this species; it was added to the UK BAP in 1997 but to date there is no published Action Plan (a species account has been compiled by the JNCC). It is not known to occur in an SSSI or other designated site. The main threats are similar to those outlined for *O. pallens* (see page 137), as too are the priorities for conservation action. It was listed as Critically Endangered in the RDB (Church *et al.*, 2001) but recent discoveries in England have seen it downgraded to Endangered on the revised British Red List.

M

BRYALES

Philonotis marchica

Bog Apple-moss

EN

BAP; NR

No change

This small, pale green acrocarp forms turfs or scattered shoots to about 10mm tall. The narrow leaves curve in one direction, are usually distinctly toothed, and are coated with a thin water-repellent cuticular wax that facilitates gas exchange when wet. It is dioicous and sporophytes (which are spherical, like an apple, hence the common name) are not known in Britain. Specialized asexual propagules are unknown in British plants. It behaves as a long-lived shuttle species, characteristic of long-lasting micro-sites.



A film of water saturates a turf of *Philonotis marchica* on a vertical sandy bank in Shanklin Chine, Isle of Wight. Photo: Jonathan Sleath.

It occupies a narrow ecological niche, on friable sandstone rock where a more or less permanent surface water-film is present (*Philonotis* is derived from Greek for 'loving moisture'). It occurs at the base of sandstone coastal cliffs and on the walls of a narrow steep sided chine (the English name 'bog' is therefore rather misleading). It often occurs in pure patches but associated bryophytes may include *Conocephalum conicum*, *Epiterygium tozeri* and *Pellia endiviifolia*.

A member of the European Southern-temperate element, it is widespread throughout Europe and is not considered threatened. It is more common in southern Europe, rather rare in northern Europe and extends east to the Balkan countries and European Russia. Elsewhere it is known from the Caucasus, N Africa, Asia, N and S America. In the BI it is known only from England. The earliest confirmed English record is 1859, by W. Wilson (1799–1871). It was found at Shanklin Chine, IoW, and he correctly identified it as *P. marchica*.



Philonotis marchica

Wilson was well aware that it occurred widely in Europe yet had never been found in Britain, but other bryologists were doubtful. Braithwaite (1824–1917) in his magnum opus *The British Moss-Flora of 1887–1905* wrote “[*P. marchica* is] a moss which has been reported more than once as British, and ought to be found here, as it is met with throughout Europe, but hitherto it has not been identified among native specimens”. H. N. Dixon (1861–1944) in his *Student's Handbook* (1954) also avowed that “the true *P. marchica* has not yet been detected in Britain”. Wilson's material resided almost forgotten in Warrington Museum until J. H. Field (1933–1995), a *Philonotis* specialist, examined it in 1969. He compared it with continental material and concluded it was *P. marchica*. But even Field's word was not enough to convince a sceptical bryological community. It was not until A. J. E. Smith examined the specimen from Warrington Museum and concurred that it was indeed *P. marchica* that it was finally and unanimously accepted as a British species (Smith, 1974). There is also a collection from Deepdale, near Bowes in Yorkshire, discovered in 1903 by W. Ingham (1854–1923). Although he initially named his plant *P. marchica*, he retracted following consultation with Dixon and later renamed it *P. rigida*, a superficially similar species, but it has been subsequently confirmed as *P. marchica*. It has not been found in Yorkshire since.

There were no further records from the IoW for some 95 years until J. Appleyard (1906–1989) collected a *Philonotis* “in some quantity” during a BBS meeting in 1964; it was named *P. rigida*. Then a second locality for *P. marchica*, confirmed by JHF, was discovered in 1978 at Little Stairs, Shanklin, by L. Snow, former County Recorder for the IoW. It was growing on wet ‘detritus’ at the foot of a sandstone coastal cliff a kilometre or so north of Shanklin Chine. When C. C. Townsend visited Shanklin in 1979 he found Snow's locality to be overgrown and could not find *P. marchica*, but he did find a small *Philonotis* sparsely scattered on wet sandstone in Shanklin Chine that he took to be *P. marchica* (later confirmed by JHF). Townsend's suspicion was aroused concerning the *P. rigida* recorded in Shanklin Chine during the BBS visit; subsequent checking of the material by JHF showed that it was, after all, *P. marchica*.

The most recent record of *P. marchica* from Shanklin Chine was made in 2002 during a BBS meeting, and there is no reason to suppose the population is not still present. Colonies were also found along the foot of the sandstone cliffs at Hope Beach and at Little Stairs. It appears to be a dynamic species, occupying suitable long-lasting micro-sites and disappearing when conditions become unsuitable. In 1995, it was reported as occurring in two places in Shanklin Chine, comprising relatively large populations, but in 2002 it was said to be in very small quantity and much reduced from earlier years. Assessments of abundance are difficult to interpret due to a lack of a quantifiable baseline survey. Nonetheless, herbarium specimens hint of larger plants in the past, with shoots up to 9 cm tall, indicating conditions are possibly now sub-optimal.

Although there appears to be no immediate threat, tourism, development and coastal protection works are risk factors. Neither Shanklin Chine nor the nearby coastal cliffs are designated but the species is on the UK BAP. There is no published Action Plan to date, but priority action should include liaison with the Local Authority to avoid or minimize the impacts of tourism, removal of any invasive vegetation, establishing a baseline against which future trends can be monitored, surveying potential habitat in the vicinity of Shanklin, and including material in the *ex situ* threatened bryophyte facility at RBGK. Given that *P. marchica* occupies a restricted range in a single hectad comprising rather small fluctuating populations it is classified as Endangered on the revised British Red List.

M

FUNARIALES

Physcomitrium eurystomum

Norfolk Bladder-moss

EN

BAP; NR

No change

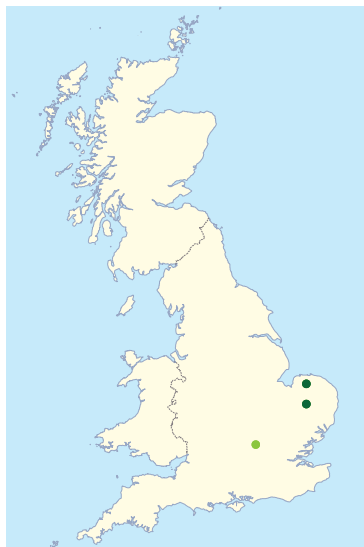
This is a small ephemeral moss forming loose or closely packed turfs with shoots to 3 mm tall. The soft broadly oval leaves have a nerve that ends in a toothed, pointed apex. The capsule is characteristically urn-shaped with a small mitriform (shaped like a bishop's hat) calyptra or cap (*Physcomitrium* means 'bladder cap'), and when mature the lid is shed to reveal a wide mouth (hence *eurys* = wide *stomum* = mouth) from which the spores are liberated. It is monoicous and sporophytes are abundant. Specialized asexual propagules are unknown. It shows an episodic life-history strategy, investing in high reproductive effort and large spores (up to 40 µm) which can remain dormant for extended periods.

This moss is a specialist of damp neutral soil or mud on the exposed draw-down zone of reservoirs and Breckland meres with a fluctuating water table, often amongst a sparse cover of herbs and grasses. It is sporadic and only appears following prolonged drought when the mud dries and cracks exposing the buried spores. It is often mixed with *Aphanorrhegma patens*, *Leptobryum pyriforme*, *Physcomitrium pyriforme* and *Riccia cavernosa*. Its character states are intermediate between the other two *Physcomitrium* species in Britain, *P. pyriforme* and *P. sphaericum* (Ducker & Warburg, 1961); recent molecular analyses suggests that it was formed from a hybridization event between ancient ancestors of the *Physcomitrium-Physcomitrella* complex since it has both *sphaericum* and *pyriforme*-type alleles (McDaniel *et al.*, 2010).

A member of the Eurasian Temperate element, it is widespread albeit regionally threatened (ECCB, 1995). It is scattered throughout C Europe, extending S to France and Italy and N to Denmark and E to Bulgaria, Romania and Slovenia. Elsewhere it is known from tropical

Africa (Kenya, Malawi, Tanzania and Uganda), Turkey, Japan, China, Hong Kong, India and New Guinea. In the BI it is known only from England.

The plant was first collected in England in 1961 by B.F.T.Ducker (an NCC officer in Norwich) at Langmere, one of about six Norfolk Breckland Meres (Ducker & Warburg, 1961). It has subsequently been recorded from Langmere in 1973, 2002, 2003 and 2005 (but this may reflect years in which the site was visited by a bryologist). The moss has been seen at four other Breckland Meres: Fowl Mere 1973; Ringmere 1990; Home Mere 1990 and a minor mere south of Mouse Hall in the 1960s. The Breckland Meres, which lie over chalk and are slightly eutrophic, are defined by their connection to subterranean aquifers and are characterized by irregular rhythms of emptying and recharge. Several years may elapse during which a mere may remain dry, followed by a prolonged period when water is constantly present. Such behaviour, where each mere has its own periodicity, may partly explain the sporadic appearance of the moss. The large spores are evidently able to remain dormant, buried in the mud, for considerable periods of time and provide a mechanism for temporal dispersal.



Physcomitrium eurystomum

This species is not exclusive to the Breckland. In December 1961 it was found by E. F. Warburg (1908–1966) on the draw-down zone of Tring (Wilstone) Reservoirs in Hertfordshire. It was seen only once more in 1969. Remarkably it was found recently, in 2006, on mud by



Physcomitrium eurystomum showing both the characteristic wide-mouthed urn-shaped capsules and the mitriform calyptra. Photo: David Holyoak.

Wicken Pond, Syderstone in N Norfolk by C. Dunster. This is the first record of this elusive plant outside Breckland since 1969.

Threats include ground water extraction, depressed groundwater levels due to successive dry winters, pollution, competition from other vegetation and artificial maintenance of high water tables. There is no specific conservation action aimed at this plant. Although it was added to the UK BAP in 2007 there is as yet no published Action Plan, but the Breckland Meres are covered by the 'Aquifer fed naturally fluctuating water bodies' Priority HAP and the meres are within the Breckland SAC. Three SSSIs support *P. eurystomum*: Tring Reservoirs SSSI in Hertfordshire; East Wretham Heath SSSI (Langmere and Ringmere) and Stanford Training Area SSSI (Home Mere) in Norfolk. Wicken Pond in N Norfolk is situated just outside the boundary of Syderstone Common SSSI. In addition to site-based management, the moss would likely benefit from a combined landscape approach, particularly within Breckland. It is important to consider connectivity between the meres; although sheep lightly graze the area, fences constrain movement and prevent wanderings between the meres. With such large spores it is likely that this species is relatively immobile, and birds and other animals may play a role in long-distance dispersal. Given the very restricted range and fluctuating populations, *P. eurystomum* is classified as Endangered on the revised British Red List.

L

JUNGERMANNIALES

Plagiochila norvegica

Bilobed Featherwort

VU

NR

Upgraded

This species is a green, moderately sized, turf-forming leafy liverwort with shoots to about 25 mm long and 4 mm wide. The slightly glossy and rather fragile leaves are bi-lobed with conspicuous teeth of varying size (some very large) around the margin; these characters separate it from the similar and widespread species *P. porelloides* and *P. spinulosa*. Sporophytes and gametangia are unknown in British plants and specialized asexual propagules are absent; it behaves as a perennial stayer.

It occurs on a single flint stone on a calcareous, wooded NE-facing slope, under an open canopy of Ash, Hazel and planted conifers (Lawson's Cypress); formerly the area supported Ash-Hazel coppice and is notable for the abundance of flints scattered over the ground. Bryophyte associates occur in small quantity but include its congener *P. porelloides* and also *Plagiothecium nemorale* and *Lophocolea bidentata*.

A European endemic, *P. norvegica* is a member of the Suboceanic Boreo-temperate element. It was described as new to science in 1988 from Norway (Blom & Holten, 1988) and was later found at another Norwegian site and at one locality in Sweden, but both have subsequently disappeared, only the type locality in Norway remaining. It is listed as endangered in Europe (ECCB, 1995). It was discovered in England in 1977 by B. Collins near Batcombe in Dorset (Hill, Collins & Edwards, 1998). It remains the only known locality for this enigmatic plant in the BI. It covers an area no more than 5 × 7 cm² on a large flint rock but does appear to be stable.

Since the plant occurs intermixed with *P. porelloides* in England and in Europe, it has been suggested that *P. norvegica* may be an aberrant form, or mutant, of that species. There was



The beautiful but enigmatic leafy liverwort
Plagiochila norvegica in Dorset. Photo: Bryan Edwards.



Plagiochila norvegica

an attempt to resolve the taxonomic question by comparing Norwegian type material with the widespread *P. porelloides* for differences in isozyme banding patterns – where enzymes differ in their electrophoretic mobility but which share the same substrate, thereby pointing to possible genetic differences (Cronberg, 2000). The results indicated that both species share the same banding pattern supporting the hypothesis that *P. norvegica* may simply be a mutant form of *P. porelloides*. However, it is equally possible that the level of differentiation is too small to be detected by the method used. In 2011, RBGE collected a few shoots for DNA barcoding, a method that uses a short genetic marker in an organism's DNA to identify it as belonging to a particular species, and it is anticipated that this will get closer to the truth. In the meantime, because the two entities are clearly morphologically distinct, *P. norvegica* is retained on the European bryophyte checklist as a valid species.

The Batcombe site, thought to have been wooded since at least 1600 A.D., is not an SSSI but it has been generously donated to the Dorset WT by B. Collins, the former owner of the site. He removed many conifers whilst at the same time promoting natural regeneration of Ash and Hazel. Some Lawson's Cypress were retained in the vicinity of the liverwort to preserve humidity and low light levels; disturbance and ensuing light influx may cause a flush of brambles and other vegetation to overrun the flint area as has happened in adjacent parts of the wood. The population and site condition is kept under surveillance by BC.

This liverwort was only recently added to the revised British Red List and was not eligible for consideration in the latest UK BAP revision. Until the genetic issue is resolved, committing scarce conservation resources may be open to challenge (see Hallingbäck, 2007); however, some would argue that the conservation of genetic variation is equally important (see the section on 'Rarity in bryophytes' on page 13). Nevertheless, its inclusion within the *ex situ* threatened bryophyte facility at RBGK should be a priority with the proviso that any further collection does not compromise its survival. Axenic or cryopreserved material will then be available for reintroduction trials if necessary,

and for ongoing molecular studies, eliminating the need to take more from the wild. Despite the population being very small and at extremely high risk of extinction, the moss is listed as Vulnerable on the revised British Red List, upgraded from Data Deficient (Church *et al.*, 2001). The British categorization is thus at variance with the European listing (ECCB, 1995), in which it is acknowledged that *P. norvegica* would qualify as Critically Endangered based on the new IUCN guidelines.

M

HYPNALES

Plasteurhynchium meridionale

Portland Feather-moss

VU

NR

No change

Formerly in the genus *Eurhynchium*, this moss is a green or yellowish-green, densely branched mat-forming pleurocarp with numerous erect branches attaining 2 cm or more in length and 2 mm wide. The broadly triangular, widely spreading, somewhat undulate leaves appear lightly pleated lengthways (plicate), taper to a long, fine point with a finely toothed margin. It is dioicous and sporophytes are unknown in Britain. It behaves as a perennial stayer.

It is a coastal plant, favouring warm, open or sheltered spots, growing on thin soil overlying limestone rocks, on tracks and stony banks, in disused quarries and in open, short grassland on cliff slopes amongst sparse grasses and herbs, and also on sheltered rocks in boulder scree. Associated bryophytes include *Fissidens dubius*, *Homalothecium lutescens*, *Neckera complanata* and *Trichostomum brachydontium*. It is also known on the chalk, in a pebble and



LEFT: The bushy Mediterranean–Atlantic moss *Plasteurhynchium meridionale* moistened by rain. Photo: Ron Porley (Portugal). RIGHT: Close-up of the leaves of *Plasteurhynchium meridionale* showing the longitudinal folds of the broad, spreading, triangular leaves. Photo: Des Callaghan.

flint scree associated with *Hypnum lacunosum*, *Scorpiurium circinatum* and *Tortella tortuosa* and several lichens.

This moss belongs to the Mediterranean–Atlantic element and is widespread in southern Europe, N to Switzerland and France (the next nearest population to Portland is just south of Bordeaux), reaching its northern limits on the south coast of England. Elsewhere it is known from Macaronesia, N Africa, Turkey and Israel. It was discovered on British shores in 1881 on the Isle of Portland, by the chemist E.M. Holmes (1843–1930) and Sir William Coles Paget Medlycott (1831–1887), baronet, amateur artist and all-round natural historian. It has been seen by a succession of bryologists at various places on the Isle of Portland over the years and since 1980 has been found in about ten distinct areas (Hill & Edwards, 2003). In 1998, a small outlying population was found by B. Edwards on the chalk summit of Bindon Hill near Lulworth, raising the possibility that



Plasteurhynchium meridionale

P. meridionale may be found elsewhere outside its Isle of Portland stronghold. A record of this plant from a limestone wall at Wells in Somerset, collected by C.H. Binstead in 1886, turned out to be a small form of *Eurhynchium striatum*, a species that can be confused with *P. meridionale*.

There is no specific conservation action focussed on this species. Most of the known populations are in two SSSIs: Isle of Portland SSSI and the Dorset Coast SSSI, both of which fall within the Isle of Portland to Studland Cliffs SAC. There is no indication of a decline, although some populations are at risk from scrub encroachment, particularly Ivy and brambles, and quarrying. It is a species that may benefit from a more Mediterranean-like climate, although its poor powers of dispersal could limit its spread. In view of its small range in Britain *P. meridionale* is categorized as Vulnerable on the revised British Red List.

M

HYPNALES

Pseudocalliergon turgescens

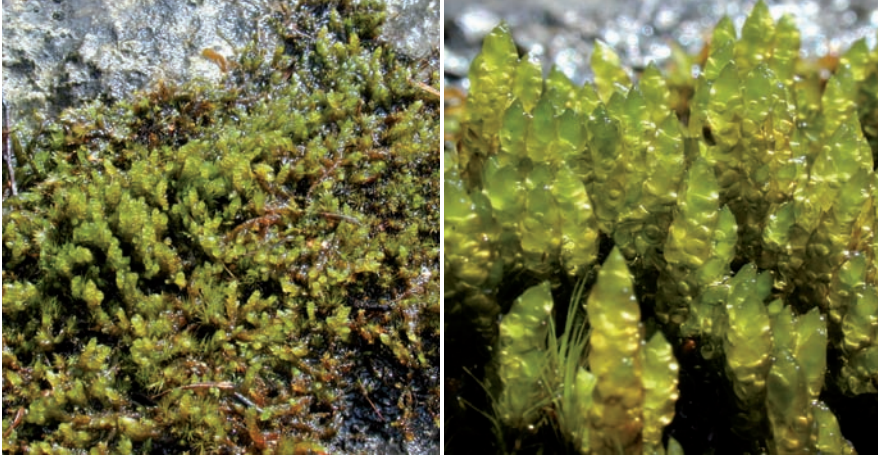
Turgid Scorpion-moss

VU

WCA; NR

No change

This is a striking moss, with sparsely branched shoots up to 25 cm long (but normally much shorter) and some 2–3 mm wide when dry, swelling to 4–5 mm when moist. It is a glossy golden-green colour when moist, turning a bronzed shade of green when dry. The densely overlapping leaves are broad and concave with a small blunt point, tightly clasping the stem, giving a worm-like appearance. It is dioicous and sporophytes are unknown in Britain, and are extremely rare in Europe. In N America and Europe the species is often propagated vegetatively by readily detached shoot apices, but such asexual propagules remain to be



LEFT: *Pseudocalliergon turgescens* spills out of hollows onto the flat limestone clints.
 RIGHT: The glossy, tumid shoots of *Pseudocalliergon turgescens* glisten in the late afternoon sun.
 Photos: Ron Porley.



Submerged and saturated, *Pseudocalliergon turgescens* fills many of the water-filled hollows in limestone pavement at Gait Barrows, Lancashire. Photo: Ron Porley.

convincingly demonstrated in Britain. It behaves as a perennial stayer, characterized by a potential lifespan of several years with low reproductive effort.

It belongs to the Circumpolar Arctic–montane element with disjunct occurrences farther south. In Europe it is recorded from Scandinavia, the Alps and Poland, and elsewhere is known from N and S America, Asia and Africa. It was more widespread in Britain during the last glaciations when open conditions prevailed, with sub-fossil remains found in Middlesex, Cambridgeshire, Worcestershire and Northamptonshire, Berwickshire in Scotland, Louth in Ireland, and indeed elsewhere in Europe, confirming its glacial relict status (Dickson, 1973). Its survival in Britain may be largely chance and it was probably

driven from the landscape by the spread of forests in early Post-glacial times.

In Britain the plant is restricted to two localities, one in England at Gait Barrows SSSI within the Morecambe Bay Pavements SAC, and one in Scotland on Ben Lawers SSSI/SAC, where it has been known since Revd. C.H.Binstead (1862–1941) collected it in 1902. It has been doubtfully recorded from Cader Idris in Wales in 1922; there is uncertainty concerning its provenance (Birks & Dransfield, 1970). In England it eluded discovery until M.E.Newton chanced upon it in 1990 when she took a group of students to Gait Barrows. It grows in shallow depressions (solution hollows) on Carboniferous limestone pavement 25 m a.s.l., often submerged in lime-rich water with a pH >8. It occurs as pure stands filling the hollow and spilling out onto the clints where it is sometimes mixed with *Didymodon ferrugineus*, *Fissidens adianthoides* and *Pleurochaete squarrosa*. It is locally abundant, scattered over an area of about 1.5 ha.

This contrasts with its habitat on the Ben Lawers mountain range in Scotland, where it grows in sedge-rich mires at 990 m a.s.l. In Europe other lowland occurrences include Öland in SE Sweden and the Pakri Islands in the Gulf of Finland, Estonia; interestingly, at both of these localities, the moss also occurs on alvar, the continental equivalent of limestone pavement.

On its English site there are no special conservation measures in place. It is fully protected under the WCA 1981 and occurs within an SSSI/SAC. Climate change aside, there is no evidence of any immediate threat. Although it is known from just two localities in Britain it has shown no evidence of decline and is therefore listed as Vulnerable on the revised British Red List.



Pseudocalliergon turgescens

M

HYPNALES

Rhynchostegium rotundifolium

Round-leaved Feather-moss

CR

BAP; WCA; NR

No change

This moss is a dullish-green mat-forming pleurocarp with creeping shoots to about 2 cm long and irregular ascending branches about 1 mm wide. The soft oval leaves, shortly pointed and with a nerve that extends to just beyond mid-leaf, are slightly twisted when dry but are flat and spreading when moist. It is monoicous and sporophytes are commonly produced. Specialized asexual propagules are absent and it behaves as a perennial stayer.

The plant grows in two distinct habitats: on the shaded boles and exposed roots of hedgerow trees including Ash and Field Maple along a farm track, and on shaded Oolitic limestone rocks on a roadside bank. Its sites are characterized by calcareous soils, typically sheltered by tree cover, in intensively farmed landscapes. The most frequently associated



LEFT: *Rhynchoszegium rotundifolium* on roadside rocks in the Cotswolds. RIGHT: A close-up of a moist shoot of *Rhynchoszegium rotundifolium* showing the broadly-oval, shortly-pointed, spreading leaves. Photos: Des Callaghan.



Rhynchoszegium rotundifolium on an Ash coppice stool in East Sussex. Photo: Ron Porley

bryophyte is *R. confertum*, although *Anomodon viticulosus*, *Homalothecium sericeum* and *Oxyrrhynchium hians* are also present in small quantity.

A member of the European Temperate element, it has a scattered distribution and is regarded as rare in Europe (ECCB, 1995). It has been recorded from The Netherlands, Germany, France, Italy, Czech Republic, Slovakia, Hungary, Bulgaria, Romania, Slovenia and Serbia. Elsewhere it is known from Turkey, the Caucasus, Asiatic Russia, Iran and Japan. In the BI it is known only from southern England. The first English record is attributed to the

Revd. C. H. Binstead (1862–1941) who collected it from stones in a hedge somewhere near Wells, N Somerset, in 1887. However, the locality is vague and it has never been found in the county since. In 1901, it was discovered at Bisley in the Cotswolds, E Gloucestershire by E. J. Elliot and G. Holmes (1835–1910) on a roadside bank on limestone rocks where it persists to this day. The third English locality was found by R. A. Boniface (1913–1985) in 1950 growing on hedgerow trees along a cart track near Wilmington, E Sussex, where the plant still survives. *R. rotundifolium* is fully protected under the WCA 1981 and in 1999 a UK BAP was published. Prior to that the species received little attention from bryologists or conservationists; indeed several decades passed during which there were no records from either of the two extant localities. Little is known of the factors involved in spore dispersal and establishment; sporophytes are produced in abundance in most years, so the species' absence from widely occurring suitable ground is puzzling.



Rhynchostegium rotundifolium

In late 1980s/early 1990s the presence of the moss was confirmed by R. Stern and N. G. Hodgetts at its historic sites in both E Sussex and E Gloucestershire. The Gloucestershire population is dynamic but appears to be stable overall; in 2008 it was estimated to occupy an area of about 216 cm² with numerous sporophytes, up significantly from estimations made in 2004 (Callaghan, 2009). The roadside bank vegetation is cut to a height of approximately 10 cm by a local farmer, which suppresses potentially competing plants. The site is not designated as an SSSI (this should be considered), but is a local wildlife site and therefore has some degree of local planning control. Under the UK BAP, there is liaison with the Highways Agency, landowners and local farmers and this should be maintained. The moss remains at risk from road maintenance, heavy traffic and over-growth by Ivy and the moss *Homalothecium sericeum*. Furthermore, the roadside bank partially collapsed some time prior to 2002 (Callaghan, 2005) although it is unclear whether the population was affected.

The Wilmington population grows on the shaded base of a coppiced Ash stool within a hedge bank, estimated in 2008 to occupy some 562 cm², with abundant sporophytes in two discrete colonies (Callaghan, 2009). The confinement to a single Ash tree means that *R. rotundifolium* is particularly vulnerable; one practical measure would be to plant Ash to provide future host trees. An active Badger sett and latrine is very close to the Ash stool, and has been since at least 1998. The moss is within Wilmington Downs SSSI and the South Downs NP.

The moss is in axenic culture in the *ex situ* threatened bryophyte facility at RBGK, but not in cryopreservation; techniques for re-establishment into the wild should be trialled. Populations in both counties should ideally be monitored annually; otherwise at least once every three years. Given the very restricted range, very few individuals and fluctuating populations, the moss is classified as Critically Endangered on the revised British Red List.

*Riccia bifurca***Lizard Crystalwort**

EN

BAP; WCA; NR

Upgraded

This is a greyish-green thalloid liverwort forming, like others of its genus, small rosettes; in this species the rosettes are between 0.5 and 15 mm diameter and sometimes coalesce to form mats. The name *Riccia* dates from 1729, and is dedicated to the amateur Italian botanist and politician Pietro Francesco Ricci, and *bifurca* refers to the forked rosettes forming roughly two halves. The thallus lobes are 'branched' 1–3 (5) times and each is no more than 1 mm wide. The key field character is the brown or orange-brown older regions of the thalli, which also become channelled with age. The margins of the thalli are typically reddish-brown and are slightly swollen. It is monoicous and sporophytes are fairly common; asexual propagules are absent. Under dry conditions it behaves as an annual shuttle, characterized by large spores and a high reproductive effort, and vanishes during the summer. In wet sites it may perennate and thus sporophytes can be found through much of the year.

It is predominately a coastal species, but extends some 5 km inland, on muddy, gravelly or thin peaty soil overlying serpentine, on moist slopes, damp or wet depressions (tolerant of occasional submersion) or tracks on cliff tops and on heaths. It favours open ground and does not tolerate competition or heavy shading. Associated bryophytes are few, but may include *R. beyrichiana* and *Archidium alternifolium*.

A member of the European Southern-temperate element, it is widespread in Europe from Iceland and Scandinavia south to the Mediterranean. Elsewhere it is known from Macaronesia, N Africa, Turkey, N America and Australasia. Its history in England is uncertain on account of the species (and other *Riccia*) being misunderstood by earlier bryologists; old poorly preserved material is also notoriously difficult to name. The situation was elucidated by Jean Paton, who made a special study of the more intractable British *Riccia* species (Paton, 1980). It emerged that *R. bifurca* was a rare liverwort restricted to the Lizard Peninsula, with small populations



LEFT: *Riccia bifurca* showing the characteristic swollen margins to the thalli. Photo: Štěpán Koval (Czech Republic). RIGHT: An extreme close-up of *Riccia bifurca* on the Lizard Peninsula in Cornwall, showing the orange colour of older parts of thalli. Photo: Des Callaghan.

chiefly found in the Kynance Cove area, north of Penhale and the Traboe Cross area on Goonhilly Downs. A lack of early specimens means that the first date of collection is not precisely known but was probably around the early part of the 20th century; authenticated material was collected on several occasions in the 1960–70s, but thereafter records declined throughout the 1990s and 2000s. There is a record for 2006 from the Kynance area, and in 2010 D.A. Callaghan found it at two spots near Kynance Farm. In 2012, DAC found hundreds of thalli in cattle-grazed turf over serpentine at Traboe Cross. All the sites from which the liverwort has been recorded since 1970 are within three SSSIs (Goonhilly Downs SSSI, Kennack to Coverack SSSI and West Lizard SSSI) and are within The Lizard SAC. It is also fully protected under the WCA 1981.

The reasons for the decline are not fully understood, but the major threat seems to be scrub encroachment due to a lack of grazing on the cliffs. There is some conservation grazing being undertaken by NE, and the NT is using highland cattle and ponies on some headlands, but this needs to be extended to other areas of the peninsula. Invasive alien plants such as Hottentot Fig are presently localized and occupy a relatively small area; nevertheless, it occupies habitat that would potentially be available to *R. bifurca*. Excessive trampling by walkers and hard-coring of tracks may be other factors. The decline in area of occupancy and extent of occurrence, and a reduction in the quality of the habitat have therefore resulted in an upgrading from Vulnerable (Church *et al.*, 2001) to Endangered on the revised British Red List.



Riccia bifurca

L

RICCIALES

Riccia canaliculata

Channelled Crystalwort

VU

BAP; NR

No change

This thalloid liverwort (see *R. bifurca* page 153 for an explanation of the origin of the name *Riccia*) forms partial bright green or yellowish, sometimes violet-tinted rosettes or intricate mats up to 20 mm diameter with thin linear thalli that fork several times; the ultimate branches are usually less than 1 mm wide. It differs from most other *Riccia* in the long, narrow branches that taper at their ends with a distinct median groove (hence *canaliculata*, referring to the channelled thalli), a character that is more conspicuous upon drying. It also has scales on its underside that curl over the extreme branch tip. This species is monoicous and sporophytes are frequent. Specialized asexual propagules are absent and it behaves as an annual shuttle with large spores and high reproductive effort.

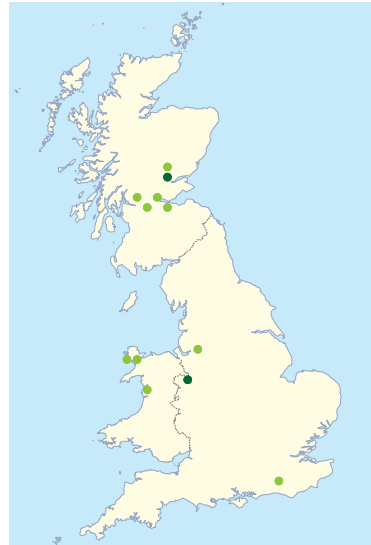
It grows on open damp base-poor mud or sand on the margins of ponds, lakes and reservoirs where it is exposed by falling water levels (draw-down zone) during dry summers. The spores apparently lie 'dormant' in the mud when covered by water and this probably accounts for



LEFT: An intricate mat of the bright-green *Riccia canaliculata*. RIGHT: A close-up *Riccia canaliculata* showing the characteristic long, narrow, channelled thalli. Photos: Gordon Rothero (Scotland).

its rather sporadic occurrence; in this respect it may be considered an episodic species. It is often found with other ephemeral bryophytes of the draw-down zone, including the Red Listed *Micromitrium tenerum* (page 129).

A member of the European Southern-temperate element, it is widespread in Europe east to Poland and Hungary. Its complete world distribution is uncertain owing to confusion with other *Riccia*, but it is known from SW Asia, N Africa, N and S America (Brazil). In the BI it is known from N Wales (from where the first British record was made in 1800), Scotland (its stronghold today appears to be in the central lowlands) and England. One of the earliest English collections was made in 1834 (as *R. fluitans*) by the leading British bryologist of the time W. Wilson (1799–1871), at Mere in Cheshire, but it was never to be seen here again. Further English records are very sporadic, although it was known from Hawkins Pond (within St Leonard's Forest SSSI) in W Sussex up to the mid-1970s and from Brown Moss SSSI in Shropshire, where it was last recorded in 2004. In 2003, it was noted that the invasive aquatic New Zealand Pygmyweed was abundant at Brown Moss although *R. canaliculata* was said to persist amongst it. There is currently no published Action Plan and an assessment of its status at its only known English locality is urgent. Other threats include alteration of the natural seasonal fluctuation of water levels, pollution and eutrophication. With a restricted range and less than five localities, the liverwort is listed as Vulnerable on the revised British Red List.



Riccia canaliculata

*Riccia nigrella***Black Crystalwort**

EN

BAP; NR

Upgraded

This is a small thalloid liverwort (see *R. bifurca* page 153 for an explanation of the origin of the name *Riccia*) forming semi-circular or nearly circular rosettes to 15 mm in diameter; individual rosettes may coalesce to form mats. It is distinguished by the dark, bluish-green sharply furrowed thallus often with purplish-black margins. The key field character is the almost black (*nigrella* = black) scales on the underside that when desiccated curl up over the thallus. It is monoicous and sporophytes are common; the capsules are embedded in the older parts of the thallus and seen as dark spots. Specialized asexual propagules are absent and it behaves as an annual shuttle with large spores and high reproductive effort.

Like other members of the genus, *R. nigrella* is a species of bare open ground and it dies back completely in the summer months. It is a coastal plant thriving in exposed situations, growing on thin neutral to acid soils that are wet in winter and dry in summer such as on cliff tops, soil overlying rocks and on rocky slopes, beside paths and on mud-capped walls. It is sometimes associated with *R. sorocarpa*, *Fossombronia caespitiformis* and *Archidium alternifolium*.

A member of the Mediterranean–Atlantic element, it reaches its northernmost world limit in Britain. In Europe *R. nigrella* is widespread and locally common throughout the Mediterranean countries. Elsewhere it is known from N and S Africa, Macaronesia, Israel, N and C America, SW Asia and Australia. The first British record, made in 1843, was from near Barmouth in Wales, while in England it was discovered much later, in 1912, by H. H. Knight (1862–1944) in Worcestershire but never re-found here.



ABOVE LEFT: The appearance of *Riccia nigrella* under dry conditions; all that can be seen is the black scales as the thalli margins curl over.

Photo: Ron Porley (Portugal). ABOVE RIGHT: Revived by moisture, *Riccia nigrella* unfurls revealing green rosettes with purplish-black thalli margins. Photo: Ron Porley (Portugal).

RIGHT: An extreme close-up of *Riccia nigrella* showing the purplish-black margins.

Photo: Des Callaghan.



In England today, *R. nigrella* is restricted to the Lizard Peninsula, an area that has one of the most Mediterranean-like climates in Britain. It was first found here in 1916 by W.E. Nicholson (1866–1945) at Housel Bay and has been found at many other localities since by a roll-call of bryological luminaries, including H.L.K. Whitehouse (1917–2000) in the 1950s and J.A. Paton in the 1960s. In 2010, D. Callaghan found it at several places (nine in total) in three SSSIs (Caerthillian to Kennack SSSI, Kennack to Coverack SSSI and West Lizard SSSI) all within The Lizard SAC. There are no specific conservation measures for the plant, but it does benefit from grazing since scrub encroachment is a widespread problem on the Lizard cliffs. The NT has instigated grazing with highland cattle and ponies in some areas, such as on Enys Head, which is now in good condition, demonstrating that recovery of neglected heathland is possible and that the bryophytes return. Invasive alien plants such as Hottentot Fig are presently localized and occupy a relatively small area of the potential habitat available to *R. nigrella*, but this issue needs tackling nevertheless. Excessive trampling by walkers and hard-coring of tracks may be other factors implicated in its decline. Management for Pygmy Rush on the Lizard is aimed at restoring a network of tracks and maintaining seasonal pools; this may also benefit *R. nigrella* and other notable bryophytes. Given that there is a decline both in terms of area of occupancy and extent of occurrence, and a reduction in the quality of the habitat, this species has been upgraded from Vulnerable (Church *et al.*, 2001) to Endangered on the revised British Red List.



Riccia nigrella

M

POTTIALES

Scopelophila cataractae

Tongue-leaved Copper-moss

VU

BAP; NR

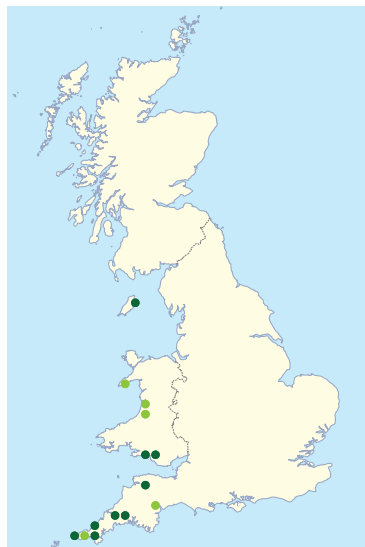
New addition

This plant, one of the so-called copper mosses, is a bright to olive-green tuft-forming acrocarp. When growing luxuriantly it can form cushions to 30 mm deep, but usually it is much less. The somewhat glossy sharply keeled leaves, golden-bronze when old or exposed to the sun, are little more than 1 mm long, widest just above the middle and with a strong nerve that ends in the abruptly tapering apex. Superficially it resembles the common moss *Barbula convoluta* but this is a distinctly yellow plant. *Scopelophila cataractae* is dioicous and sporophytes are unknown in Europe and only male plants have been found. Specialized asexual propagules occur in the form of filamentous protonemal gemmae, and rhizoidal tubers have been noted from N Wales and mainland Europe.

It is a lowland plant of heavy, metal-rich rocks, or soils derived from them, and the generic name reflects its preference for a rocky or stony habitat such as spoil mounds. It favours humid sites, in particular on steep or vertical clayey or silty ditch or stream banks that drain



Scopelophila cataractae growing on metal-rich mine waste in Cornwall. Photo: Des Callaghan.



Scopelophila cataractae

ground rich in metallic ores, including copper, zinc and tin. It grows in both full light and in partial shade under heather or sheltered overhangs. More rarely it grows on thin soil in crevices of walls in old mine workings. It is intolerant of competition but occasionally grows with *Cephaloziella nicholsonii* (page 75) and *C. stellulifera*. This plant not only illustrates an inherently broad tolerance of heavy metals, it actually seems to require metal-rich soils for optimal growth making it ecologically a very interesting plant; indeed it shows greatest cover and biomass, with more robust individuals, on mine spoil (Shaw, 1993). Heavy metal ions are effectively immobilized in the cell wall and may be the main mechanism of tolerance in bryophytes (Tyler, 1990).

A member of the Circumpolar Southern-temperate element, it has a very wide but disjunct geographic range spanning several continents. In Europe it is known from France, Belgium, The Netherlands, Germany, Italy and Spain. Elsewhere it occurs in N, C and S America, Asia, C Africa, Indonesia, Philippines, Japan and Korea. Intriguingly, it was recently reported from Thailand, high (40 m above ground) on the trunks of forest trees, with sporophytes (Akiyama, 2010). Sexual reproduction is normally absent or apparently very rare. A possible explanation of its wide distribution is long-distance dispersal of leaf fragments acting as asexual propagules. In the BI it is known from Ireland (three localities), Wales and England. It was first found in Wales in 1967, new to Europe, collected from mine spoil in the Lower Swansea Valley, although a decade passed before the identity of the plant was resolved (Corley & Perry, 1985). The first English record was made in 1985 near Chudleigh in S Devon, collected by A. C. Crundwell (1923–2000) in company with two visiting American bryologists W.R. Buck and A. J. Shaw. Its occurrence on industrial waste gave rise to speculation that it might be an introduction and hence it was omitted from the previous Red List (Church *et al.*, 2001), but the current consensus is that it is a native plant.

Recent fieldwork by D. T. Holyoak has revealed the English stronghold for *S. cataractae* to be in W Cornwall, a reflection of the legacy of the once vast mining industry. Since the first report

in 1994, the plant has been recorded from some 14 sites; about 20% of the Cornish population is within the composite W Cornwall Bryophytes SSSI and a small population occurs on Penberthy Croft Mine SSSI. It is much less frequent in E Cornwall, where it is known from three sites: Phoenix United Mine SSSI and Crow's Nest SSSI (Phoenix United Mine and Crow's Nest SAC), and a site near Warleggan (notable for supporting a large population) that is within the Cabilla Manor Wood SSSI. In S Devon it has also been recorded from three sites, but has not been seen here recently. It was found on the Isle of Man in 2000 by T. L. Blockeel, also a region that witnessed extensive mining in the past, and in 2009 it was discovered in N Devon by DTH but does not occur on any Devon SSSIs. Although listed as Nationally Rare (Preston, 2010), recent fieldwork has shown that it actually qualifies as Nationally Scarce; it is known from about 22 sites in England, from 17 10 km squares.

Although the medium-term outlook for the species looks good, losses have been documented. Development and general tidying up of disused mine sites continues to threaten some populations, as does tipping, but possibly the principal long-term threat is natural leaching of metals from the spoil, scrub encroachment and neglect. The extent of suitable habitat is declining and new exposures of ore-laden rocks will need to be created if *S. cataractae* is to survive in the long term. Its addition to the revised British Red List as Vulnerable is in recognition of a predicted decline and loss of habitat.

M GRIMMIALES

Seligeria brevifolia
Short Rock-bristle

VU	NR
No change	

This is a minute, light-green moss forming loose turfs with shoots to 1mm tall. The narrow, rather short leaves (hence *brevifolia*) have an indistinct nerve ending below the blunt leaf tip. It is monoicous with inverted pear-shaped capsules on short setae produced in abundance. Specialized asexual propagules are unknown and it behaves as a colonist. The genus commemorates Ignaz Seliger (1752–1812), a Silesian pastor, notary and florist.

In England the plant grows in recesses in vertical Millstone Grit or sandstone rock faces in moist shaded moorland sites at moderate altitudes (around 400 m). Elsewhere in the BI it grows under overhanging rock and on base-rich pumice. Associated bryophytes include *Blindia acuta* and *Tetradontium brownianum*.

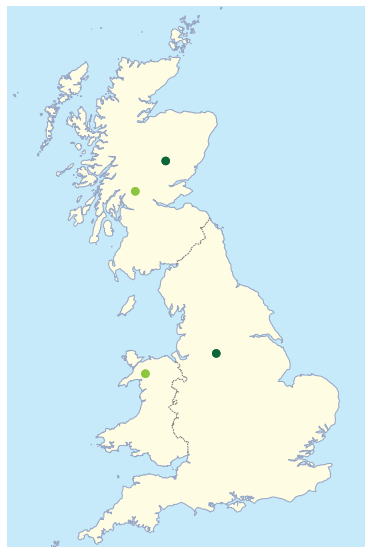
A member of the Eurosiberian Boreal-montane element, it is apparently rare and disjunct throughout the northern hemisphere. In Europe its status is insufficiently known (ECCB, 1995) but it has been recorded from Iceland, Scandinavia, Austria, Switzerland and the Pyrenees. Elsewhere it is known from a few sites in



Seligeria brevifolia with capsules showing the widely spreading peristome teeth.
Photo: Tommy Petterson (Sweden).

Siberia (the Ural Mountains), the Caucasus and eastern N America (Atlantic Canada). In the BI it is known from Scotland, Wales and England. The first English record was found by T.L. Blockeel in 1986, on crags above a stream at Ashop Clough, a valley (locally termed 'cloughs') on Black Ashop Moor in the Peak District NP, Derbyshire. TLB checked its status in 1993, 2003 and most recently in 2010 and the population was judged to be stable.

Until recently, *S. brevifolia* was known from just four sites in the BI (two in Scotland, one in Wales and one in England), but in 2010 TLB discovered a second English population covering several square centimetres with abundant sporophytes on low Millstone Grit crags above a stream at Grindsbrook, Edale, two or three kilometres SW of the original population and within the Peak District NP. There is no specific conservation action directed towards this moss and it is not listed on the UK BAP. Both English populations are within the Dark Peak SSSI and the South Pennine Moor SAC. Apart from the vulnerability conferred by small populations, there does not appear to be any significant threat to the plant. Since the plants tend to grow in crevices, competition from other plants is avoided or is minimal. On the basis that it is restricted to five or fewer locations, *S. brevifolia* is classified as Vulnerable on the revised British Red List.



Seligeria brevifolia

M

GRIMMIALES

Seligeria carniolica

Water Rock-bristle

CR

BAP; NR

No change

This is a minute moss, only 2–3 mm tall, which was originally described from Carniola (within modern day Slovenia) in 1882. It has bristle-like leaves that taper abruptly from an oval base to a long point, filled largely by nerve; they are directed to one side and curve downward in a wide arch. It is monoicous but sporophytes are rare. The characteristic 'top-shaped' capsule, held on a stout seta, has 16 short peristome teeth that radiate out like the spokes of a wheel, giving the moss its former name *Trochobryum carniolicum* (*trocho* = wheel like). The capsule lid remains attached to a central stalk (columella) until quite old and is almost flat except for a small central boss. Specialized asexual propagules in the form of protonemal gemmae are known in culture and in the wild. It exemplifies a short-lived shuttle life-history strategy.

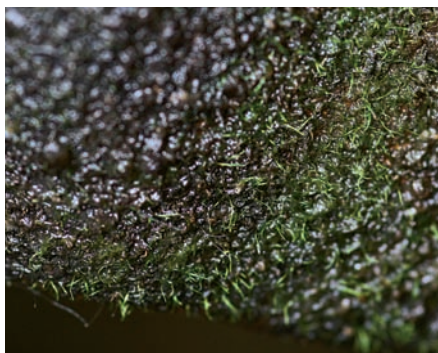
In England, the moss grows on calcareous sandstone or impure limestone beside a shaded streamside at an altitude of about 200 m, and may be submerged or exposed depending on water levels. The water is circumneutral, oligotrophic and with a high oxygen concentration. *S. carniolica* is not tolerant of competition from other bryophytes but the impure limestone rocks may also support *Dichodontium pellucidum* and *Rhizomnium punctatum*.

This species is a European endemic and belongs to the Suboceanic Boreal–montane element with scattered occurrences in Germany, Switzerland, Austria, Slovenia, France, Sweden and Norway. Many of these countries support a single population, and therefore it is listed as endangered in Europe (ECCB, 1995). Many of the localities in Europe are in areas thought to have remained relatively ice-free during the last glaciation and it is considered a possible late ice-age relict (Dickson, 1973). The first record from the BI was made in 1948 in Black Burn, Roxburghshire, Scotland, gathered by Miss E.M. Lobley (1902–1977). It has not been seen since in Scotland despite repeated attempts to re-find it. Then, in 1964, Miss Lobley, with a small party of bryologists turned up another population, some 40 miles east in SNorthumberland (Lobley, 1965), in a small burn, a tributary of the River Coquet in the Simonside Hills. It grows on hard water-smoothed calcareous sandstone rocks that are subject to periodic submergence. The deep-cut burn is sparsely wooded with a light canopy of birch, Alder, Sallow, Hazel and oak, and on the banks a number of bryophytes occur, including *Hyocomium amoricum*, *Pellia endiviifolia* and *Scapania undulata*.



Seligeria carniolica

The English population is within the Simonside Hills SSSI/SAC and was one of the earliest bryophytes to have a published Action Plan under the UK BAP. In 2000, as a contribution



ABOVE LEFT: The slender, hair-like shoots of *Seligeria carniolica* growing on shaded sandstone rock. Photo: Richard Lansdown.



ABOVE RIGHT: *Seligeria carniolica* with *Rhizomnium punctatum* on hard sandstone rock in the Simonside Hills, Northumberland. Photo: Richard Lansdown.

RIGHT: *Seligeria carniolica* with capsules.

Photo: Tomas Hallingbäck (Sweden).



to the plan, three colonies were marked by the insertion of electronic chips into the rocks on which the plant grows. The electronic chips, detected using a hand-held device, enables colonies to be re-located, logged and monitored. Concerns about agricultural run-off led to water samples being taken in 2000 to determine the Diatom Quality Index and Trophic Diatom Index. These indices, based upon the composition of the diatom community, indicated that the water is typical of an upland fast-flowing stream. There was no indication of nutrient enrichment that might put the plant at risk. Further water samples should be taken in the future as part of a monitoring programme. Visits post-2000 have re-found some colonies (on one rock a colony occupied about 20cm²) whilst other colonies have disappeared and previously undetected colonies discovered indicating the dynamic nature of this shuttle species. The most recent visit in 2008 for the UK BAP reporting purposes assessed it as stable. It is held in the *ex situ* conservation of threatened bryophyte facility at RBGK. Since *S. carniolica* occurs at a single locality occupying about 50 m length of stream that supports less than five colonies, it is on the revised British Red List as Critically Endangered.

M

GRIMMIALES

Seligeria diversifolia

Long Rock-bristle

VU

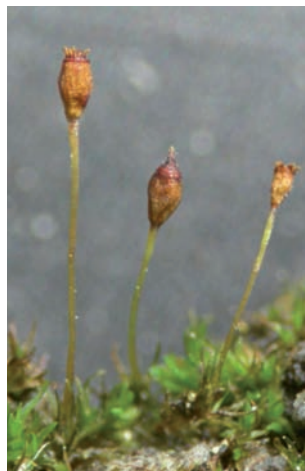
NR

New addition

All *Seligeria* are tiny, and this species is no exception (for derivation of name, see *S. brevifolia* page 159). It is a yellow-green acrocarp forming loose turfs with shoots to 2.5 mm tall. The leaves increase in size up the stem (hence *diversifolia*, referring to leaves of different size), the uppermost are about 2 mm long in sterile shoots and they taper to a bluntly pointed tip that lacks teeth. It is monoicous and the abundant ovoid capsules are held on a straight seta 2–4 mm long (as opposed to no more than 1.5 mm long in *S. brevifolia*). Specialized asexual propagules are unknown and it behaves as a colonist.

In England it is a plant of wooded calcareous cliffs of an abandoned limestone quarry of the Upper Jurassic. Immediate associates are not recorded but *S. recurvata* is plentiful in the area (but that species has a curved seta, hence its name).

A member of the Circumpolar Boreal–montane element, this species is rather rare throughout its range. It is not considered threatened in Europe and occurs in Sweden, Finland, Norway, Svalbard, northern Russia and Switzerland. Elsewhere, it has been reported from Siberia, the Caucasus, Arctic Alaska, Quebec, Greenland, Ellesmere Island, eastern N America and China. In the BI it is known from Scotland and England. The first British record was made in 1971 by the late F.E. Branson from limestone cliffs at Wass Bank, a disused quarry near Ampleforth in Yorkshire (Crundwell & Nyholm, 1973). The BBS returned to Wass Bank in the summer of 1997



Seligeria diversifolia – doubts exist whether this species truly occurs in England.

Photo: Tomas Hallingbäck (Sweden).

with the objective of re-finding *S. diversifolia*. Despite the combined search power of several bryologists it was not found, only numerous colonies of *S. recurvata* were seen, a few of which had virtually straight setae. This prompted some uneasiness amongst the party; it is possible the original identification is a misidentification and the herbarium material upon which the English record is based should be critically examined. The only other British record, from Westernness in Scotland, has not been seen since its discovery in 1984.

Little is known about this nationally rare and rather inconspicuous moss. There is no conservation action, it is not on the UK BAP list and the English locality is not within a designated site. Any threats are unknown. Another search of the English locality would be a priority if the original herbarium voucher is confirmed. In the RDB (Church *et al.*, 2001), *S. diversifolia* is listed as Data Deficient, but on the basis that it is restricted to five or fewer locations it has been reclassified as Vulnerable on the revised British Red List.



Seligeria diversifolia

L

JUNGERMANNIALES

Solenostoma caespiticium

Delicate Flapwort

VU

NR

Upgraded

This plant, formerly known as *Jungermannia caespiticia*, is a yellowish to pale green leafy liverwort that forms smooth mats with individual shoots reaching 5 mm long to 1.2 mm wide. The closely overlapping leaves, inserted on either side of the stem, are more or less round and sometimes slightly concave. It is dioicous and perianths and sporophytes are rare in Britain. Specialized asexual propagules are often present as dense apical clusters of green unicellular gemmae surrounded by 1–2 pairs of strongly concave leaves. The rather variable shaped gemmae have an endogenous origin within the stem apex, a unique feature in the order Jungermanniales. It behaves as a pioneer colonist with a reliance on asexual propagules for population maintenance.

It is found in temporary, otherwise ordinary and widespread habitats, growing on moist acid clay, loam, sand or gravelly soil and occasionally on metal-rich mine soils, typically in sheltered niches in moorland, on stream banks and reservoir margins. It occurs on thin soils derived from Millstone Grit in the north of England and on sandstone in southern England. It is intolerant of competition and often grows in pure patches. Other liverworts such as *Calypogeia* spp., *Nardia scalaris* and *Solenostoma gracillimum* sometimes grow in association.

A member of the European Boreal–montane element, this liverwort is not considered threatened throughout C and N Europe, but is on the limits of its southern range in Britain where it is known from England and Wales (last record 1972). Elsewhere it is known from



ABOVE LEFT: The closely overlapping orbicular leaves of *Solenostoma caespitium*, looking very much like its common associate *Solenostoma gracillimum*. ABOVE RIGHT: *Solenostoma caespitium* in its typical habitat of bare, open ground. RIGHT: The dense apical clusters of green unicellular gemmae surrounded by pairs of strongly concave leaves in *Solenostoma caespitium*.



Photos: Štěpán Koval (Czech Republic).

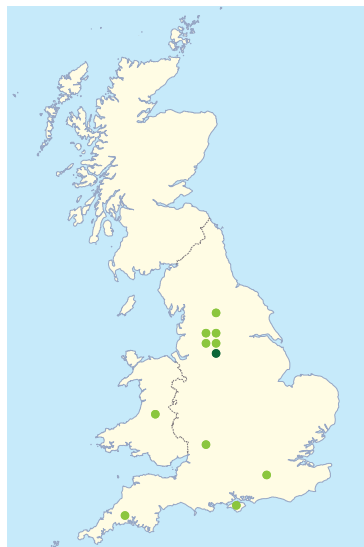
N America and Siberia. The earliest British record, dated 1908, is from the Wilderness, near Godshill on the IoW. It was found by H. H. Knight (1862–1944), but has never been found here since. He also found it new to Surrey in 1910 from sandstone near the top of Leith Hill (not seen since), and in the company of his friend D. A. Jones (1861–1936) he found it new to E Gloucestershire in 1915 at Pilford brick-pits on the edge of Cheltenham; it persisted here at least until 1931.

Several records were made in SW Yorkshire in the mid-1940s by, amongst others, H. Walsh (1881–1962). HW had his 'eye in' for the plant and found it in reasonable quantity in the Calderdale area, and by the mid-1950s had found it in about 13 localities (Walsh, 1957). T. L. Blockeel found it at Blake Dean in 1978 and a further three localities in the county up until the early 1980s. He also discovered it new to mid-West Yorkshire in 1983 at Upper Skell Gill in Wensleydale, new to Derbyshire in 1987 at Woodlands Valley in the Peak District NP, and in 1993 from William Clough, near Kinder. TLB returned to Woodlands Valley in October 2011, and amongst much *S. gracillimum* he found the plant at two localities at Gate Side Clough in small amounts on moist gritty soil. The plants were diminutive and delicate in appearance, with incipient gemmae and immature perianths; he noted that it probably would have been have overlooked if not specifically searched for, verification that targeted survey does work.

In SW England, in 1963, J. A. Paton discovered a colony at Luckett, E Cornwall, growing on damp mineral rich spoil of abandoned arsenic works, last seen here in 1970. Then, in October 2011, D. A. Callaghan discovered a small colony (about 5 cm²) on a bank of metal-rich spoil amongst tall heather in the Lower Carnon Valley, SW of Truro. The record, which is new to W Cornwall, is also too recent to be mapped. The liverwort has been recorded from a total of eight English vice-counties in about 21 localities; today it is known from two vice-counties.

The apparent historic decline may not be as dire as this suggests; the species may be overlooked, particularly when it grows with *S. gracillimum* and *Nardia scalaris*, both of which are very similar in appearance. Nevertheless there is little doubt that this liverwort is rare and perhaps erratic in appearance. Its limited dispersal potential in Britain, a possible correlation with wet years (Walsh, 1957), and a preference for impermanent niches and intolerance of competition, could be factors contributing to its rarity.

Since *S. caespiticium* had not been seen for ten years or more it was not eligible for inclusion on the UK BAP; consequently there are no explicit conservation actions. Some of its northern localities are within the Dark Peak SSSI and South Pennine Moors SAC. Targeted survey of historic sites, particularly the within the Calderdale area, is a priority. Consideration should be given to including it in the *ex situ* threatened bryophyte facility at RBGK. It is listed as Near Threatened (Lower Risk) in the RDB (Church *et al.*, 2001) but has been upgraded to Vulnerable in the revised British Red List in recognition of its restricted range and occurrence at fewer than five localities since 1980.



Solenostoma caespiticium

L

JUNGERMANNIALES

Southbya nigrella

Blackwort

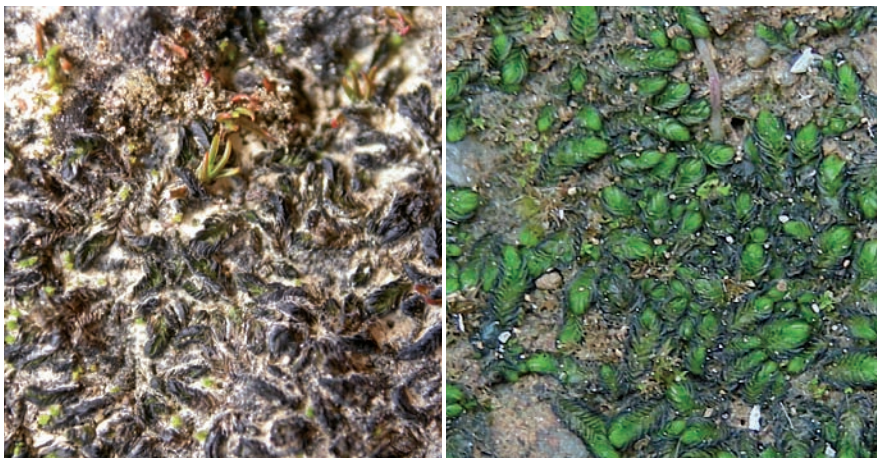
VU

BAP; WCA; NR

No change

Southbya, named in honour of Anthony Gapper Southby (1799–1883) of Bridgwater, Somerset, is a genus of small leafy liverworts with opposite rounded leaves that is represented in Britain by two species. This species has creeping shoots no more than 5 mm long and less than 1 mm wide. It often forms intricate but sparse mats, with light green shoot tips and characteristically dark green older parts. When dry the leaves furl exposing black scaly undersides (hence *nigrella*). It is monoicous and sporophytes are fairly frequent. Asexual propagules are unknown. It behaves as a pioneer species, with a high investment in reproductive effort and a relatively long lived gametophyte. Microscopic examination is needed to separate it from *S. tophacea* (page 167) but their range in England does not overlap.

It grows on calcareous soils close to the sea, usually where shaded, in short broken turf often around rocky outcrops and on cliff-tops, on thin clayey or sandy compacted soil sometimes creeping over other mosses, on abandoned limestone quarry floors, and directly on limestone rocks. It is adapted to a Mediterranean type climate characterized by hot dry summers and mild wet winters. In the summer months growth is suspended and the gametophyte withers and is almost invisible, with the black undersides of the leaves affording UV protection. With the return of moisture the desiccation tolerant shoots unfurl and growth resumes.



LEFT: When desiccated the presence of *Southbya nigrella* is only made known by the exposed black ventral scales. RIGHT: The true beauty of *Southbya nigrella* is revealed when revitalized by rain or dew. Photos: Ron Porley (Portugal).

It belongs to the Mediterranean–Atlantic element with its northernmost stations in Britain. In Europe it is frequent throughout the Mediterranean region and elsewhere it is known on the N African coast, in SW Asia (Iraq) and the Canary Islands. In the BI, *S. nigrella* is restricted to the S coast of England, known from the Isle of Portland, Dorset, and from the SW tip of the IoW.

The liverwort's stronghold is on the Isle of Portland SSSI and the adjoining Nicodemus Heights SSSI, most of which falls within the Isle of Portland to Studland Cliffs SAC. It was discovered new to Britain in 1921, on Portland, by the distinguished Sussex bryologist W. E. Nicholson (1866–1945). It is currently known from about 20 localities on Portland (Hill & Edwards, 2003), several of which contain hundreds of plants, although at others the population is small. There is no management on the SSSI specifically aimed at this dynamic species; it exploits the thin, rabbit-grazed and drought stressed soils. Threats on Portland include expansion of quarrying, illegal dumping, recreational pressures and other land-use changes. The liverwort may also be at risk from the spread of invasive shrubs including *Buddleja* and *Cotoneaster*.

On the IoW the plant was first recorded during a BBS visit to the island in 1964 at St Catherine's Point, an area difficult to access due to frequent landslips and therefore the plant is infrequently reported. It occurs on shaded friable limestone boulders and on the ground immediately below them. During the summer months moisture evaporates and



Southbya nigrella

the boulder 'skin' exfoliates taking the liverwort off with it; this dynamic process provides fresh substrate for recolonization. Burial by landslip may deplete some populations but it also provides opportunities. The site is within the Compton Chine to Steephill Cove SSSI and the South Wight Maritime SAC but there is no specific management aimed at *S. nigrella*. The NT, part-owner of the land, has undertaken some scrub clearance in the past, but accessibility is a hindrance to further work. Possibly because of the unusually dry spring, a visit by C. Pope at the end March 2011 failed to find *S. nigrella* here.

This rare liverwort is on the UK BAP list and fully protected under the WCA 1981. It is important that population trends are monitored at least once every six years within the framework of the SSSI/SAC surveillance programme. Light shade in the summer may benefit *S. nigrella* and therefore the risk posed by *Buddleja* is uncertain and should be investigated. Since it belongs to the Mediterranean–Atlantic element, *S. nigrella* might be favoured by climate change. However, sea level is rising at a rate of about 5 mm per year due to isostatic rebound and ice melt (Hughes, 2003), and land slippage may be further exacerbated by an increased frequency and intensity of winter storms. It is listed as Vulnerable on the revised British Red List as it occurs at just two sites in England.

L

JUNGERMANNIALES

Southbya tophacea

Green Blackwort

VU

NR

Upgraded

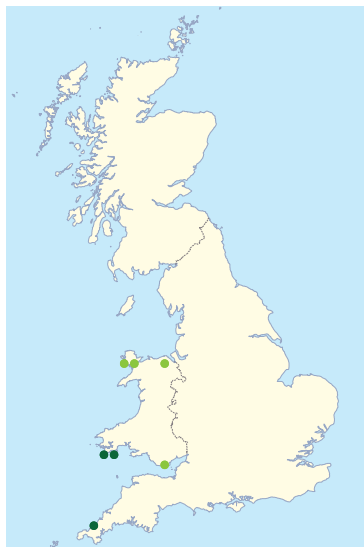
Named by the intrepid explorer and naturalist Richard Spruce (1817–1893) after its predilection for sandy soils (Latin *tophaceus* meaning sandy or gritty), this species is a small creeping leafy liverwort with shoots not more than 6 mm long and 1 mm wide. It has opposite, oval to round leaves that overlap and nearly touch above the stem when moist. It closely resembles *S. nigrella* (page 165) but it is normally a lighter green or a pale yellowish-brown colour, not the characteristic dark green to black colour of that species. The moss is dioicous and sporophytes are fairly frequent. Asexual propagules are absent and it behaves as a colonist.

It is a calcicole and in England grows on wet or dry base-rich sandy or clay soils, on spoil from abandoned tin mines and on open bare ground such as tracks in old dune systems. It occurs as pure patches on bare ground, usually sheltered but open, associated with the tiny liverwort *Leiocolea turbinata*, the mosses *Pleurochaete squarrosa* and *Trichostomum crispulum* and, at Perranporth, the lichen *Fulgensia fulgens*. Although the liverwort shows a connection with past metal extraction industry, it is unlikely that it has a preference for metal-rich soils as any copper or tin has been leached from the mine spoil a long time ago, as evidenced by other associated plants.

A member of the Mediterranean–Atlantic element, it reaches its northernmost localities in the BI. It is frequent in the Mediterranean region and extends eastwards to SW Russia. Elsewhere it is reported from SW Asia, N Africa and Macaronesia. In the BI it occurs on the Welsh coast, where it occupies a wide range of niches; two localities in Ireland, but only one re-found post-1980 (Lockhart, Hodgetts & Holyoak, 2012); and in England, where it is known from two areas on the Cornish North Atlantic coast.



A close-up of *Southbya tophacea* showing the round leaves arranged oppositely along the stem typical of the genus. Photo: Des Callaghan.



Southbya tophacea

Confusion with *S. nigrella* (page 165) meant that *S. tophacea* was not recognized as a British plant until 1960, when J.A. Paton collected fruiting material at Gear Sands, Perranporth (Paton, 1961); it was, however, collected from here earlier in 1940, by E. W. Jones (1909–1992). It is still present at its two Cornish localities at Gear Sands within Penhale Dunes SSSI/SAC (Perranporth) and Godrevy to St Agnes SSSI/SAC (Porthtowan). In recent years it was known to occur in some abundance amongst sparse open vegetation on old mine spoil at Gear Sands, although surveillance in 2012 suggests that it may have declined. However, with no detailed baseline to assess change it is difficult to be certain (Callaghan, 2012). The population at Porthtowan is much smaller.

There is no specific conservation measures aimed at *S. tophacea* in England and it is not on the UK BAP. Threats to this liverwort are unknown but may include scrub encroachment. It was listed as Lower Risk (Near Threatened) in the RDB (Church *et al.* 2001) but given that it has declined from five hectads pre-1980 to three post-1980 it has been upgraded to Vulnerable on the revised British Red List.

M

SPHAGNALES

Sphagnum balticum

Baltic Bog-moss

EN

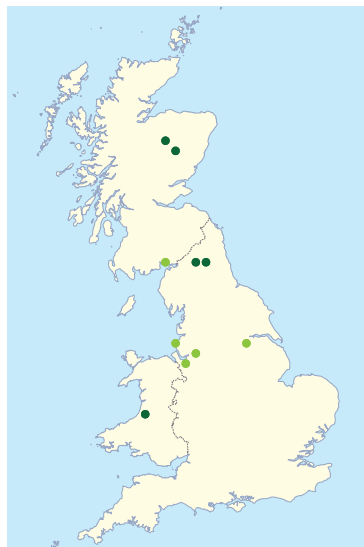
BAP; WCA; NR

No change

This species forms brownish or orange, loosely packed turfs comprising slender upright stems to 15 cm tall. The bog-mosses are usually immediately recognized by their distinctive growth form, in particular the capitulum (head) of short, densely arranged branches atop a weak stem that carries numerous clusters (fascicles) of limp branches with leaves that closely overlap, often in neat ranks. Bog-mosses are considered unrelated to other ‘true’



The orange-brown shoots of *Sphagnum balticum* amongst red shoots of *Sphagnum magellanicum* on Muckle Moss, Northumberland. Photo: Ron Porley.



Sphagnum balticum

mosses and are placed in a class of their own, the Sphagnopsida. *Sphagnum balticum* is a member of section Cuspidata with spreading stem leaves and bunches of three branches (fascicles) on a pale stem. It is dioicous and sporophytes are unknown in Britain. It is a mobile species and dispersal is probably by fragmentation (as in most *Sphagna*, even where they do fruit), and it behaves as an early successional colonist.

It is primarily a moss of nutrient-poor raised bogs that are fed by rainwater (ombrotrophic) but is also found on marginal areas of valley bogs and more rarely blanket bogs. It favours a relatively high water table (about 5 cm below the surface) forming cushions or carpets in wet depressions and hollows. Optimal growth requires very cold winters and minimal disturbance.

A member of the Circumpolar Boreo-Arctic Montane element, it is widespread in the Baltic countries and is typically continental in its distribution. It extends as far south as the Alps and is on the eastern edge of its range in Britain. Elsewhere it is known from northern Asia, N America and Greenland. In the BI it is known from Scotland, Wales (both with recent records) and England. The first English record is 1863, at Oakmere, Cheshire, found by G. E. Hunt (1841–1873). Although Oakmere survives as an example of a lowland oligotrophic mere developed over a series of kettle holes, no raised bog exists today and the plant is presumed extinct in Cheshire. There is also a record dated 1898 from Netherton Carr, S Lancashire, collected by J. A. Wheldon (1862–1924), but this site has long since disappeared. More recent finds are from Thorne Moors in SW Yorkshire, the first record dating from 1932. This site has experienced extensive drainage and peat cutting and *S. balticum* was last recorded here in 1980 by T. L. Blockeel. The one remaining site in England, at Muckle Moss in S Northumberland, was discovered around 1961–63 by *Sphagnum* expert Miss E. M. Lobley (1902–1977) and Miss M. Dalby (d.1978). There are few subsequent records from Muckle Moss.

In 2000, J. Turner, working for Plantlife International funded by EN to take forward the UK BAP, organized a visit to Muckle Moss with the aim of assessing the status of *S. balticum*. A team was assembled, with representatives from EN, CEH, NHM, Northumberland WT

and other *Sphagnum* specialists, including A.G. Payne. A local newspaper (*The Journal*) also attended the event. It was reported as ‘an expeditionary force of experts from all over Britain’ and featured an iconic picture of moss hunters in action. *S. balticum* is scattered over an area of approximately 5 ha and is associated with *S. magellanicum*, *S. capillifolium* ssp. *rubellum* and occasionally *S. papillosum*. Unlike more northerly mires in Europe, *S. balticum* is not closely associated with *S. majus* and *S. cuspidatum*, although these do occur in water-filled hollows at Muckle Moss.

The species is fully protected under the WCA 1981 and Muckle Moss is designated as an SSSI. Conservation of *S. balticum* is habitat orientated, with the aim of maintaining high water levels, and this appears to be benefitting the plant. Drains have been blocked and some invasive pines have been removed. The site is remote (Hadrian’s Wall is not far away) and consequently is little disturbed apart from light cattle grazing. The long-term threats to populations in Britain are climate change, particularly a trend towards higher winter temperatures and raised CO₂, and atmospheric nitrogen deposition. The response of *Sphagnum*, including *S. balticum*, to these factors is well documented (e.g. Van der Heijden *et al.*, 2000), but it is the complex interactions in the vegetation that make it very difficult to predict precise outcomes; the implications for a Boreal species on the south-eastern edge of its range is uncertain. The extent of *S. balticum* should be monitored every five years, whilst keeping disturbance to a minimum. As a further conservation measure, material should be incorporated into the *ex situ* threatened bryophyte facility at RBGK. As the plant is restricted to a few localities in Britain, where its populations are declining and the habitat quality is deteriorating, it is classified as Endangered on the revised British Red List.

M

SPLACHNALES

Splachnum vasculosum

Rugged Collar-moss

VU

BAP; NS

New addition

This is a pale to dark green tuft-forming moss with shoots to 7 cm tall. The soft glossy leaves are broad, almost round, with a nerve that ends below the short, bluntly pointed apex. It is dioicous and like other members of the family it has a distinctive capsule. The apophysis (the base of the capsule) is conspicuously inflated and forms an almost globular dark purple structure that is wrinkled and pitted when dry. Held aloft on a thin red seta, it releases volatile aromatic compounds and provides visual cues to attract flies that facilitate spore dispersal (entomophily). The spores are sticky and adhere to visiting insects in contrast to wind-dispersal-adapted spores. Specialized asexual propagules are unknown and it behaves as a short-lived shuttle species.

It occurs on animal dung in flushes and springs in boggy moorland usually at high altitudes. It tolerates high nutrient status but does not withstand competition from other mosses. Little is known of its ecology, but observations from Scottish sites suggest that it requires dung only for initial inoculation and then spreads beyond as the dung patch decomposes; it may occupy many metres of a flush and can persist for several years.

A member of the Circumpolar Arctic-montane element, it is widely distributed in the northern hemisphere. In Europe it is known from Scandinavia, Svalbard and Iceland extending S to Britain, Germany, Estonia and European Russia. Elsewhere it is known



A dung-fly, attracted to volatile compounds released by the capsules, settles on a cushion of *Splachnum vasculosum*. Photo: Gordon Rothero (Scotland).

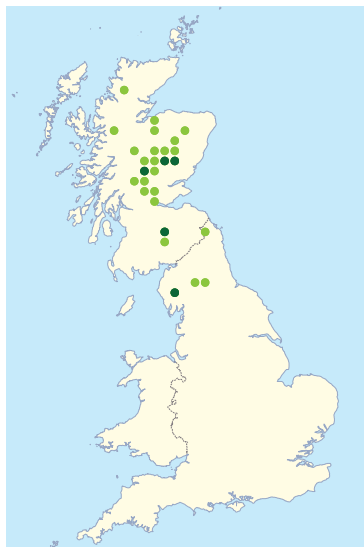
from Asian Russia, Kazakhstan, Kyrgyzstan, China, northern N America and Greenland. In Britain it is known from Scotland (its stronghold) and England. The first English record, 1833, is from Mickel Fell in NW Yorkshire (collector unknown). Ten years later W. A. Wheldon (1862–1924) found it at Teesdale, the first and last county record.

The plant has been recorded from seven English localities in four vice-counties. In 1933, U. K. Duncan (1910–1985) found it at The Bizzle in the Cheviot Hills in N Northumberland and it was re-found here by J. Appleyard (1906–1989) in 1963. In Westmorland it was collected by C. D. Pigott in 1958 at Little Fell, south of Kirby Stephen, and CDP and D. A. Ratcliffe (1929–2005) saw it at the same locality in 1962. In 1965, it was discovered at Crinkle Crag, Langdale, by an unknown collector. It was to be nearly 40 years before the next English records were made. Two populations were discovered by R. W. M. Corner during a day's hike on the Lake District fells in 2004, at Stygbarrow Crag, Westmorland and in a spring at Stygbarrow Dodd, literally 4 km over the border in Cumbria, a new county record. There have been no records from England since, but in Scotland it has been seen recently (2009).

The records suggest that *S. vasculosum* has always been rare in England, perhaps because this Circumpolar Arctic–montane species, a moss of high mountains, is on the southernmost edge of its range in Britain; Dickson (1973) listed it as a possible late glacial relict with a wider distribution in the past. The species is currently classified as Nationally Scarce (Preston, 2006) in Britain as there several occurrences in Scotland, but even here it has declined in recent years. Other dung mosses have also declined in parts of the BI and whilst this is partly due to habitat loss or modification (such as drainage), it may also be due to the use of broad-spectrum veterinary drugs (such as Ivermectin) used as a routine control for gastrointestinal and respiratory parasites in cattle, horses and sheep (Porley & Hodgetts, 2005). Such drugs ultimately end up in the dung where they have been shown to have an insecticidal effect on dung-living insect larvae. Dung is a patchily distributed substrate and recruiting flies to disperse the sticky spores to fresh dung (targeted dispersal) before other potential competitors colonize is clearly a successful evolutionary strategy, but also one that has high costs and only

functions if the vector is present (all the flies so far identified as vectors are not uncommon in the BI). Much more research is needed to understand the complex interplay between moss, vector and environment. It is likely that land use and animal husbandry changes, combined with an overall decline in habitat quality and possible climatic factors, have conspired against *S. vasculosum*.

The species was added to the UK BAP in 1997 but as yet there is no published Action Plan or any specific conservation action in England. The post-2000 populations are not within an SSSI. The recent discoveries suggest that further populations may be present in suitable habitat and priority action should be survey of historic and potential areas, preferably as a wider assessment of the status of dung-mosses in England. The condition of the sites supporting extant populations should be monitored and, if possible, management favourable to the species' requirements put in place. Axenic cultures sourced from Scotland are held in the *ex situ* threatened bryophyte facility at RBGK. It was classified as Near Threatened in the RDB (Church *et al.*, 2001), but on the evidence of a decline and reduction in habitat quality, *S. vasculosum* has been added to the revised British Red List as Vulnerable.



Splachnum vasculosum

L

JUNGERMANNIALES

Telaranea europaea

Irish Threadwort

EN

BAP; NR

Upgraded

This is a delicate, yellowish-green leafy liverwort forming smooth glistening mats of very slender, interwoven shoots that are 15–25 mm long and barely 1 mm wide. *Telaranea* is from the Latin *tela* (web) + *aranea* (spider or spiders' web) alluding to the delicate cobweb-like appearance of the shoots. The leaves consist of, usually, three hair-like erect leaf lobes one cell wide inserted on a basal lamina that is only half a cell high; underleaves are present but very tiny. It is monoicous and sporophytes are fairly frequent. Specialized asexual propagules are present in the form of club-shaped multicellular bulbils that readily detach to form new plants. It behaves as a colonist. Formerly known as *T. nematodes*, Engel & Merrill (2004) showed that all plants with this name from Europe are in fact *T. europaea*, an undescribed species, and that true *T. nematodes* does not occur in Europe.

It is a coastal plant of cool shady humid sites on moist but well-drained peaty banks and on thin soil over rocks. It is frequently found under woodland canopies including *Rhododendron* and other evergreen shrubs. It is intolerant of competition and cannot withstand desiccation. It sometimes occurs in pure patches but it is also associated with other shade-tolerant liverworts such as *Calypogeia muelleriana*.



LEFT: The interwoven, thread-like shoots of *Telaranea europaea*, one of the few plants that can thrive under a dense canopy of *Rhododendron*. RIGHT: The shaded rocky and wooded habitat of *Telaranea europaea* at Trevelloe, Cornwall. Photos: Des Callaghan.

A member of the Hyperoceanic Southern-temperate element, *T. europaea* is a European endemic and confined to areas with a mild humid climate. It is found in the oceanic regions of France, Spain, Portugal and Macaronesia. In the BI it occurs in Ireland (where it is locally frequent, hence the common name) and at one locality in SW England. It was first collected in England in 1852 by J. Ralfs (1807–1890) in private grounds at Trevelloe Carn, S of Penzance near the coast. The final record of the 19th century, from the same locality, is dated 1881, collected by the self-taught Cornish hepaticologist W. Curnow (1809–1887). The same population was re-found in 1968 by J. A. Paton on peaty soil between granite outcrops under *Rhododendron* in private grounds at the head of a ravine at Trevelloe Carn; two further records were accrued from visits to the site in the 1990s.

The most recent check on the plant at Trevelloe was made in 2012 by D. A. Callaghan as part of a NE-commissioned project to assess the status of the UK BAP bryophytes in Cornwall. Five colonies of the liverwort were found in humid crevices and on shaded walls of a tor at the head of a ravine below a canopy of Beech trees and shrubs including *Rhododendron*, Cherry Laurel and Ivy; possibly other colonies survive in inaccessible gaps between boulders. Data loggers installed adjacent to colonies suggest that the temperature rarely if ever attains sub-zero, and for 80% of the time it is within the range 6–14°C. It is remarkable that this tiny plant has persisted for so long at this site.

The species was added to the UK BAP in 1997 but an Action Plan has yet to be published (a species account has been compiled by the JNCC). The plant's only known site in Britain does not have any statutory protection. It is apparently under no



Telaranea europaea

immediate threat at its Cornish site; the current owners are sympathetic to its conservation. The shelter provided by *Rhododendron* within the woodland almost certainly contributes to the constant high humidity required by the liverwort. Ironically, whereas in other parts of Britain a constant resource-draining battle ensues to eradicate invasive *Rhododendron*, its removal at Trevelloe would be damaging to *T. europaea*. Consideration should be given to including the species in the *ex situ* threatened bryophyte facility at RBGK. On the basis of one relatively small population at a single locality, it has been upgraded from Vulnerable (Church *et al.*, 2001) to Endangered on the revised British Red List.

L

JUNGERMANNIALES

Telaranea murphyae

Murphy's Threadwort

VU

NR

New addition

This is a tiny yellowish-green to dark green leafy liverwort forming wefts of slender intertwined shoots 20–30 mm long and barely 1 mm wide. The leaves consist of usually four hair-like erect leaf lobes one cell wide inserted on a basal lamina that is up to 3·5 cells deep (as opposed to half a cell deep in the Red Listed *T. europaea*, page 172). It is dioicous but only male inflorescences are known. Specialized asexual propagules are unknown and it behaves as a colonist.

It grows on damp peat, humus and sandy soils, on leaf-litter, decorticated logs and stumps, and on the bark of pine tree bases. It occurs in humid and shady plantations of pine and *Rhododendron*, in wet willow scrub, and along lightly shaded track-ways. It often forms pure patches but is also found with other shade-tolerant liverworts such as *Calypogeia mulleriana*, *C. fissa*, *Lepidozia reptans*, *Nardia scalaris* and *Lophocolea* spp.



The true provenance of *Telaranea murphyae* is unknown; nevertheless the Isles of Scilly provides a favourable home. Photo: David Holyoak.



Telaranea murphyae

This species stands apart from all other bryophytes on the British Red List. It is regarded as non-native although its actual provenance is unknown. Globally, this enigmatic liverwort is so far known only from England, but because it occurs in or near a botanic garden it is suspected of being an introduction, perhaps inadvertently brought into this country on imported plants. Engel & Merrill (2004) in their taxonomic and phylogenetic study of *Telaranea* could not match it to any other known species (there are about 98 species worldwide, with the highest diversity in western Melanesia and Australasia). It is placed in the Oceanic Temperate element.

First detected in 1961 on Tresco, IoS, 28 miles off the SW tip of the Cornish mainland, it was initially named *T. europaea*. Closer examination by J. A. Paton revealed that it differed from that species in several respects, including sexuality. When all attempts to identify it failed, it was named *T. murphyae* (Paton, 1965) after its discoverer Rose J. Murphy. Further visits to Tresco in the 1970s, 1980s and 1990s showed that the plant was gradually spreading from banks and logs just outside the Abbey Gardens to humid sites within the Gardens and on Abbey Hill, and into wet woodland northeast of the Abbey (Paton & Holyoak, 2005). In 2003, JAP and D. T. Holyoak found it on another island, St Mary's, on Lower Moors and in a garden close to Hugh Town. Meanwhile, in 1996, it turned up in Branksome Chine, Poole in Dorset, found by N. Woods. It occurs here on soil under *Rhododendron*, and more rarely on sandy soil covering a rotten log in what was once a formal garden. About 1 km east, in the same hectad, it was found on sandy banks in Alum Chine, Bournemouth, just inside S Hampshire by R. C. Stern in 2002.

Non-native species do not meet the criteria for UK BAP listing and there are no specific conservation measures for this plant. Currently it is virtually confined to anthropogenic habitats such as botanic gardens and other areas modified by landscaping and planting, but it does occur on the edge of a path on Lower Moors SSSI, St Mary's, notified for its range of wetland habitats including topogenous mire. The IoS are situated more or less where the Atlantic Ocean meets the English Channel and experiences an oceanic climate with mild wet winters and mild sunny summers. With most days in the year above 5°C it is not surprising that plants from the southern hemisphere can gain a foothold here. Other non-native bryophytes with known Austral origins that were first found on the IoS, all initially on Tresco, include *Lophocolea semiteres* (1955), *Lophocolea bispinosa* (1962) and *Calyptrochaeta apiculata* (1967). The first two have since spread into semi-natural habitat in many counties throughout Britain, whereas the latter species is so far known from only one other site on the southern English coast. Currently *T. murphyae* is known from three hectads but its distribution may expand in Britain. At the moment, though, it has a very small range and it is included on the revised British Red List as Vulnerable because Britain, indeed England, has sole responsibility for it.

M

HYPNALES

Thamnobryum angustifolium

Derbyshire Feather-moss

EN

BAP; WCA; NR

Downgraded

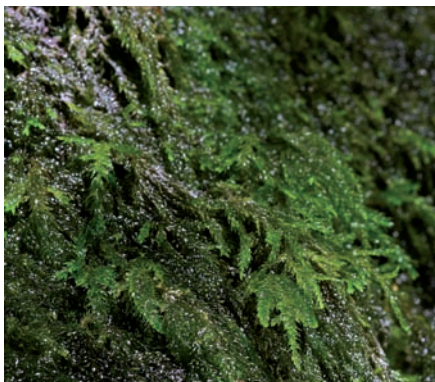
This moss is a medium-sized pale green pleurocarp forming rough dendroid mats, sometimes lime-encrusted, with shoots up to 4 cm long. Scale-like stem leaves are triangular, whereas the branch leaves are narrow (hence *angustifolium*) and linear with a thick nerve

and coarsely toothed margins. The leaves, seen in transverse section under the microscope, are more than one layer of cells thick (multistratose), a feature shared by the Red Listed *T. cataractarum* (page 178). It superficially resembles the common *T. alopecurum* but in that species the leaves are broader and only one cell layer thick with a thinner nerve and smaller marginal teeth. The plant is dioicous; only male plants are known and thus sporophytes are unknown. Specialized asexual propagules are absent and it behaves as a perennial stayer.

It is an aquatic moss, submerged in strong water currents for much of the year, but is exposed in very dry summers when water levels fall. It grows on shaded Carboniferous limestone and Permian Sandstone and is associated with *T. alopecurum*.

A member of the Oceanic Temperate element, it is endemic to England and is one of only four British bryophytes on the IUCN World Red List. It was discovered in 1883 by the Mancunian pharmacist G.A.Holt (1852–1921) on a boulder over which a torrent of water cascades in the Derbyshire Dales. A specimen collected in 1898 by J.Shepley, supposedly from Ireland, was identified by H.N.Dixon as *T. angustifolium* (recently confirmed) but its provenance is in doubt so the record has never been accepted.

The Derbyshire Dales locality is one that the bryological community aspires to be tight-lipped about, but it has been visited by many British and foreign botanists eager to see what has been, for over 100 years, the only known population of this endemic moss in the world. For a long time doubts were expressed whether *T. angustifolium* was a distinct species or merely a habitat form of *T. alopecurum*. A biometric study that compellingly showed that a number of character states were maintained in culture resolved the issue (Furness & Gilbert, 1980). Hodgetts & Blockeel (1992) supported the view that *T. angustifolium* is distinct, and furthermore is closely related to another English endemic *T. cataractarum* (page 178),



ABOVE LEFT: The English endemic *Thamnobryum angustifolium* showing the narrow, linear leaves. Photo: Des Callaghan.

ABOVE RIGHT: *Thamnobryum angustifolium* drenched by spray in the Derbyshire Dales. Photo: Richard Lansdown. RIGHT: The River Eden at Armathwaite, a new locality for *Thamnobryum angustifolium*, discovered recently along its rocky banks.

Photo: Colin Smith.



as well as to a Madeiran species. Genetically, *T. angustifolium* is identical to *T. alopecurum* but differs morphologically, and so is termed a 'morphospecies', being derived from the surrounding *T. alopecurum* population in response to extreme environmental conditions (Olsson *et al.*, 2009).

The moss has achieved some notoriety in recent years, fuelled by a story appearing in the *Guardian* newspaper in the late 1990s that told of visitors sworn to secrecy and guided to the Derbyshire site blindfolded. Whether or not the tale in the *Guardian* newspaper carries any truth is not important; what matters is that bryophytes were given much needed publicity. However, Derbyshire's sole claim to *T. angustifolium* came to an end in 2008. Whilst bryologizing during a period of exceptionally low water levels on the River Eden near Armthwaite, Cumbria, M. Lawley collected a curious aquatic moss from normally submerged rocks (Lawley, 2008). Astonishingly it turned out to be *T. angustifolium*, doubling the number of known sites in England to two and shifting the distribution farther north. A full assessment of its status along the Eden is awaited, but initial signs are that the population is more extensive than that in Derbyshire.

The species is fully protected by the WCA 1981 and was one of the first bryophytes to have a UK BAP, although the Derbyshire site has long been under surveillance by *EN* staff. The Cumbrian site is within the River Eden and Tributaries SSSI/SAC and the Derbyshire population (the anonymity of the SSSI is preserved in recognition of the sensitivity of the site) lies within the Peak District NP. As cavers are known to use the Derbyshire site and could potentially damage the population, liaison with user groups is essential; a notice warns cavers to take great care not to disturb plants. An annual habitat condition assessment and a population assessment every 3–6 years should be undertaken, and water quality and flow levels monitored. It should also be considered for inclusion in the *ex situ* threatened bryophyte facility at RBGK.

Even if *T. cataractarum* is genetically identical to *T. alopecurum* (Olsson *et al.*, 2009), it is essential that such 'morphospecies' are protected; they represent a unique opportunity to understand molecular and morphological evolution in mosses. Material is also being 'barcoded' by a team at RBGE, a technique based on the principle of using a standard short region of DNA as a universal tool for identifying organisms. The aim of the project is to establish a large-scale reference sequence database against which unknown samples can be queried for identification. Where sequences are found that are divergent from others in the database, the corresponding specimens are further investigated as potential new species.

The status of *T. angustifolium* has been downgraded from Critically Endangered (Church *et al.*, 2001) as a result of a second population being discovered in 2008; it still faces a very high risk of extinction and is classified as Endangered on the revised British Red List.



Thamnobryum angustifolium

Thamnobryum cataractarum
Yorkshire Feather-moss

EN

BAP; NR

Upgraded

This species is a medium-sized, dark green to blackish moss forming rough mats with dendroid shoots up to 5 cm long. The scale-like stem leaves are triangular whereas the branch leaves are narrow and parallel sided with a very wide nerve and with obscurely toothed margins. The branch leaves are often eroded away leaving a tangle of stiff wiry stems. The leaves, as seen in transverse section under the microscope, are more than one cell layer thick (multistratose), a feature shared by the Red Listed *T. angustifolium* (page 175). Gametangia (male and female parts) and sporophytes are unknown. Specialized asexual propagules are absent and it behaves as a perennial stayer.

It is an aquatic moss growing mainly on vertical or very steeply sloping rock in a zone several centimetres below normal summer water level, typically in strong currents. It also occurs sparsely just above the waterline with *T. alopecurum* and by waterfalls (hence the name *cataractarum*), where it is often associated with *Cinclidotus fontinaloides* and *Platyhypnidium riparioides*. It is able to tolerate very low light levels and grows at greater depths, up to 25 cm below summer water level, than any of its associates. The rock is base-poor Ingletonian grits and shales, but the water is influenced by the surrounding Carboniferous limestone and the streams draining from it.

A member of the Oceanic Temperate element, it is endemic to England and is listed as vulnerable in the European RDB (ECCB, 1995). The plant was discovered in 1991 by N.G. Hodgetts at Twistleton Glen, a deep ravine incised by the River Doe, near Ingleton in Yorkshire and was initially thought to be *T. angustifolium* (exciting enough!). NGH returned with T.L. Blockeel, and with more material available for study it was concluded that this was a new species with a number of significant differences from other closely related *Thamnobryum* (Hodgetts & Blockeel, 1992).



ABOVE LEFT: Narrow, parallel-sided leaves on wiry stems are characteristic of the English endemic *Thamnobryum cataractarum*. Photo: Fred Rumsey. RIGHT: *Thamnobryum cataractarum* grows submerged on rocks in the turbulent River Doe in Twistleton Glen, North Yorkshire.

Photo: Ron Porley.

Twisleton Glen is well known for its Atlantic bryophyte flora several of which are at the eastern limits of their British distribution. It is a local beauty spot just inside the Yorkshire Dales NP and is watched over by the Ingleton Scenery Company. It is within Thornton and Twisleton Glen SSSI and there is no immediate threat to the moss. Water quality and quantity are however risk factors; an active quarry is not too far away and could potentially affect the catchment area. The species is currently known from about six locations over some 1 km of the River Doe. Submerged under swift-flowing water, the plant is largely inaccessible; this makes direct monitoring problematical. Under the UK BAP framework an indirect monitoring methodology has been developed based on an annual evaluation of a number of site attributes such as water flow conforming to normal seasonal flow volumes, presence of Dippers (which are particularly sensitive to the effects of pollution) and general bryophyte cover on rocks. Specialist input by a bryologist is essential every ten years or so when water level is low to assess the status of the population.



Thamnobryum cataractarum

Consideration should be given to including this plant in the *ex situ* threatened bryophyte facility at RBGK. Although *T. cataractarum* and *T. alopecurum* are genetically identical they differ morphologically, termed a 'morphospecies' (Olsson *et al.*, 2009). However, it is vital such populations are protected, the reasons for which are explained under *T. angustifolium* (page 175). Given the very small population at a single known location, *T. cataractarum* has been upgraded from Vulnerable to Endangered on the revised British Red List.

M

TIMMIALES

Timmia megapolitana

Indian-feather Moss

VU

NR

New addition

Timmia, commemorating the German botanist J.C. Timm (1734–1805), is a taxonomically isolated genus of moss consisting of only four species worldwide, of which three occur in the BI. Only one, *T. megapolitana*, occurs in England. This species is a green to yellowish-green acrocarp, often covered in silt, forming compact or loose tufts with individual shoots to 4 cm tall. The specific epithet *megapolitana* refers to a region in NE Germany, although it was not originally collected from there. The relatively long leaves, up to 8 mm, taper to a fine point and have coarse single teeth along the more or less parallel sided leaf margins. When dry the leaves are contorted and wavy but spread widely when moist. Superficially, *T. megapolitana* closely resembles *Atrichum undulatum* but this has lamellae or 'ribs' of tissue along the upper surface of the nerve. It is monoicous and sporophytes are occasionally produced, although many apparently fail to mature. The English name refers to the calyptra, which remains attached

to the top of the seta and sticks up behind the capsule like a feather worn by an Indian brave. Asexual propagules are absent and it exemplifies a colonist life-history strategy.

It occurs in wet willow carr woodland in an area of medieval peat cuttings influenced by tidal movements of the North Sea. It is partially inundated by fresh water twice a day, and in winter months may remain under water for more than two days. It grows as extensive turfs on decumbent silt-covered willow branches, on vertical willow trunks just above ground and on stumps where tidal flow washes away litter accumulations. Occasionally it colonizes the exposed root-mats of the willow and, more rarely, occurs on the bases of Alder. A well-defined zonation is evident on willow trunks, with *T. megapolitana* occupying a zone more or less at ground level, *Lunularia cruciata* (a thalloid liverwort) the zone above that, and finally a zone of *Rhynchostegium confertum* and *Brachythecium rutabulum* above that.

A member of the Circumpolar Temperate element, it is a lowland plant (the other *Timmia* are mountain plants) with a wide distribution throughout the temperate zone. In Europe it is known from The Netherlands (recently discovered), Finland and old records from Poland and Germany. Elsewhere it is known from northern Asia (Russia and Siberia), Greenland and is widespread in N America. The plant was discovered in England in 2000 by R. W. Ellis at Wheatfen, a tidal marsh in the Yare Valley in the Norfolk Broads (Porley & Ellis, 2002). Subsequent visits by BBS members estimated the size of the population to comprise over 100 discrete colonies over a distance of some 400 m. Much of the area is impossible to access on foot and a boat is essential to navigate the labyrinth of channels. It is likely that the plant has been overlooked in this little-recorded habitat where few bryologists venture. Its presence here may be explained by passage in or on a bird; there does appear to be a close correlation between the European distribution of the plant and bird migratory routes, particularly geese and ducks (Porley & Ellis, *op cit*).



ABOVE LEFT: A rotting stump provides a niche for fruiting *Timmia megapolitana* at Wheatfen, Norfolk. ABOVE RIGHT: *Timmia megapolitana*, superficially resembles *Atrichum undulatum* but lacks lamellae on the nerve. RIGHT: Tidal silt-laden wet woodland, the habitat of *Timmia megapolitana* at Wheatfen, Norfolk.

Photos: Ron Porley.



No specific conservation action is directed at this plant and threats appear to be minimal, but may include water pollution and/or eutrophication from agricultural run-off. Wheatfen is managed as a nature reserve in memory of the late T. Ellis DSc., F.L.S.(1909–1986), a celebrated Norfolk naturalist and broadcaster. It occurs within the Yare Broads and Marshes SSSI and the Broads SAC, and the area is listed as an SPA and is also a Ramsar wetland site. The plant is not on the UK BAP and is not mentioned in the European bryophytes RDB (ECCB, 1995) or listed on any European convention or annex, but nonetheless is clearly a very rare and threatened plant in Europe. It is placed on the revised British Red List as Vulnerable in recognition of its single known location in England.



M

HYPNALES

Timmia megapolitana

Tomentypnum nitens

Woolly Feather-moss

VU

NS

New addition

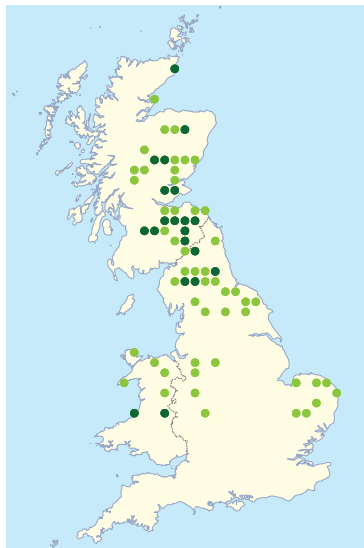
This moss is a moderately robust, yellowish-green to golden-brown pleurocarp forming rough mats or scattered shoots to 10 cm long. The stems are creeping or ascending and a dense brownish tomentum (covering of rhizoids) gives the lower stem a woolly appearance (*Tomentypnum* means a *Hypnum* with tomentum). Rhizoids also occur on the back of the nerve at the leaf base. The shiny (hence *nitens*) leaves are narrowly triangular, tapering to a fine point and have several longitudinal folds (plicate). It is dioicous and sporophytes are rare. Specialized asexual propagules are unknown and it behaves as a perennial stayer.

It grows in base-rich or calcareous mires or flushes in which there is some groundwater movement or hillside flushing, typically developed over a mineral or peaty substrate. It is one of the so-called 'brown mosses', a group of pleurocarpous mosses, mostly in the family Campyliaceae, indicative of rich-fen. The dense tomentum on the stem wicks external water upwards, thereby encouraging the development of an aerobic zone (acrotelm) positioned above the deeper peat layers.

A member of the Circumpolar Boreo–Arctic Montane element, it occurs widely in the cold Arctic and northern boreal zones and is rare in the mountains in C Europe south to Spain. Elsewhere it is known from the Caucasus, C Asia, China and New Mexico. In the BI it is known from Ireland, Wales, Scotland and England. The earliest known English record dates from around 1840 when it was collected at Lackford Bog, north of Bury St Edmunds in W Suffolk, by the botanist, keen cricketer and Sheriff for Suffolk Sir C. J. F. Bunbury (1809–1986). The last and only other record in Suffolk was made in 1978 at Weston Fen by H. J. B. Birks. In Norfolk, the moss was known from several valley fens including Royden Common, Swangey Fen, Buxton Heath and Holt Lowes but it disappeared from the county around 1970; it is probably now extinct in East Anglia. There are early collections from



The shiny golden-brown shoots of *Tomentypnum nitens*, a moss of base-rich mires and flushes. Photo: Biopix A. Neumann (Finland).



Tomentypnum nitens

Yorkshire, including Coneysthorpe in 1842 and Terrington Carr in 1850 by explorer-naturalist R. Spruce (1817–1893), and in 1870 from Halnaby Carr by the former Keeper of Kew Herbarium J. G. Baker (1834–1920). The last record from Yorkshire was made by H. J. B. Birks in 1963 from Malham Tarn.

In common with other western European countries, populations in England have been in decline over many decades. It has been recorded in a total of 15 English vice-counties, but from only nine post-1960, and just two post-2000: Helton Fell near Ullswater, Westmorland and Bakethin in the Kielder Forest, S Northumberland. It is possible that the species persists elsewhere in northern England, for example in Cumbria and Durham where D. A. Ratcliffe (1929–2005) and R. W. M. Corner made several records in the 1950s and 1960s. It was once more widespread as revealed in the Pleistocene sub-fossil record (Dickson, 1973), and the historic decline of the plant is probably due to climatic factors; work in Sweden has shown that the growth of *T. nitens* decreases with increasing temperatures (Birks *et al.*, 1998). Its disappearance from southern England and elsewhere in recent times has been exacerbated by the drainage of fens and its sensitivity to enrichment by nitrogen and phosphorus and general neglect. The decline was obscured by an increase in recording activity; between 1963 and 1978 the number of 10 km squares for *T. nitens* in Britain and Ireland increased from 38 to 86 (Watson, 1985). Recently there have been a number of new sites discovered in Scotland and it is listed as Nationally Scarce, but overall the decline in Britain has been unremitting.

It is not on the UK BAP and no extant English populations appear to be within SSSI or SAC. Survey of historical localities and targeting of base-rich fen sites for overlooked populations is a priority, particularly in northern England where a metapopulation may exist within the Scottish Borders region. Material from a range of sites should also be incorporated into the *ex situ* threatened bryophyte facility at RBGK and the level of genetic variation in populations assessed. Sporophytes are rare in *T. nitens* and dispersal of spores, or indeed any other propagule, over long distances in a fragmented landscape is probably minimal.

A promising development is that research in Sweden has shown that it is possible to reintroduce a range of rich-fen bryophytes using gametophyte fragments to restored fen sites (Mälson & Rydin, 2007). Given that *T. nitens* has undergone a severe decline, and that its rich-fen habitat is also under threat, it has been classified as Vulnerable on the revised British Red List.

M

POTTIALES

Tortula cernua

Flamingo-moss

EN

BAP; WCA; NR

No change

This moss is a small, bright green acrocarp forming tufts that are sometimes 10–30 cm across and between 3–5 mm tall. Its leaves, variable in shape, gradually taper from the base to a long pointed apex or are broadest above middle. The leaf margins are recurved and bordered by narrow elongate cells and the nerve extends beyond the apex. The leaves twist when dry, but spread when moist. It is monoicous and sporophytes are common. Specialized asexual propagules are unknown and it behaves as a short-lived shuttle species. It is the distinctive curved and slightly drooping (hence *cernua*) capsule with an obliquely pointed beak, unusual among members of its genus, held on a reddish wavy seta that gives the moss a whimsical resemblance to a flamingo's head.

It occupies a very narrow niche on bare, fine-textured, often sandy, alkaline lime kiln waste, typically sheltered from direct sunlight, often in humid hollows. It occurs on steep

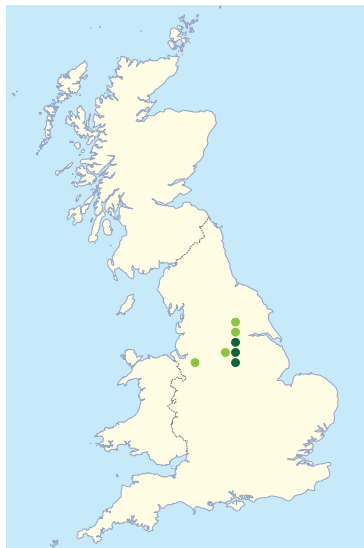


ABOVE LEFT: *Tortula cernua* is characterized by its asymmetric curved capsules held aloft on wavy stalks. Photo: Fred Rumsey. BELOW LEFT: Wizedened capsules of *Tortula cernua* that have set free their spores to the wind. Photo: Michael Lüth. ABOVE: The specialized niche of *Tortula cernua*, undisturbed alkaline spoil waste in the Don Valley, South Yorkshire.

Photo: Tom Blockeel.

banks of dumped lime-waste but also on gently sloping to level sites. The lime waste is typically weathered to a dirty pink colour with a compacted surface (Blockeel, 2000) within which the moss is partially buried. The pH of the lime waste is high (8.7–9.2), limiting some nutrients such as phosphate, potassium and calcium; magnesium levels are elevated (Headley, 2006). It is able to grow in sparse to moderate shade but does not survive burial by leaf-litter or tolerate competition.

A member of the Circumpolar Boreal–montane element, it is scattered throughout W, N and C Europe, where it is chiefly montane, and is listed as rare in Europe (ECCB, 1995). In the N of its range it is predominately a plant of natural habitats, whereas farther south it occurs primarily in anthropogenic habitats, always on alkaline substrate. Elsewhere it occurs in natural habitats in Greenland, Newfoundland, N America and C Asia. The first report of *T. cernua* in Britain was in 1900 near Aberford, mid-West Yorkshire, by G. Webster (1851–1924). However, the first collection was much earlier, around 1877–1880, by the Sheffield botanist and rural postman Amos Carr (c.1829–1884), on imported spoil at Bell Hagg in the Rivelin valley; the identity of the plant was not known at the time (Blockeel, 2000).



Tortula cernua

It has been recorded from five English vice-counties and some 20 localities, most overlying Magnesian Limestone in Yorkshire, Nottinghamshire and Derbyshire. It also occurred in Cheshire at Plumley Lime Beds growing on alkaline waste but has not been seen since. From 2000 onwards it is known to occur at five sites in SW Yorkshire and one site in Nottinghamshire. Given favourable conditions *T. cernua* can persist for long periods; it has been known from the Don Valley since 1909. Many sites have nevertheless been lost due to landscaping, use of quarries for landfill and re-working of quarries (it is intolerant of disturbance).

It is fully protected under the WCA 1981 and a UK BAP was published in 1999. It is held in axenic culture in the *ex situ* threatened bryophyte facility at RBGK but not in cryopreservation. The Nottinghamshire site is managed in sponsorship with Lafarge Aggregates, and *T. cernua* was showcased at the 2004 annual Quarry Products Association event where best practice on sensitive environmental restoration is shared. Plantlife International, with funding from NE/EN, undertook several surveys and the sites are under regular surveillance. Although most of the populations are small and sporophyte production fluctuates from year to year, plants can number in the 1,000s and at a site near Sprotbrough it is estimated to be in the millions. Populations are known to occur in two SSSIs, Lindrick Golf Course and Sprotbrough Gorge, both in S Yorkshire.

The activity that created suitable habitat for *T. cernua*, the lime-burning industry, has all but ceased. The challenge is to maintain existing populations (metapopulations) and create new habitat. Natural weathering processes gradually ameliorate the substrate, and other plants, initially small mosses, then herbs, grasses and eventually trees colonize and *T. cernua* disappears. The key is to scarify areas of lime kiln waste bringing relatively un-weathered

spoil to the surface on which spores can germinate. Preliminary studies suggest a significant spore bank is absent, thus survival is dependent upon regular sporophyte production. Given its small range, a decline in extent and quality of its habitat, a decline in extent of occurrence and area of occupancy, *T. cernua* is classified as Endangered on the revised British Red List.

M

POTTIALES

Tortula cuneifolia

Wedge-leaved Screw-moss

EN

BAP; NR

Upgraded

This moss is a small, bright green acrocarp forming low tufts or scattered shoots less than 5 mm tall. The soft concave leaves are variable in shape but typically are wedge-shaped and widest above the middle (hence *cuneifolia*); the plain margins lack a differentiated border and have a nerve that projects just beyond the leaf tip as a short or sometimes longer yellowish or silver hairpoint. Braithwaite (1887) notes that the older leaves tend to lose their chlorophyll and become diaphanous (translucent). This is one of a number of similar looking *Tortula* species including the Red Listed *T. solmsii* (page 186), *T. vahliana* (page 188), and *T. wilsonii* (page 190), for which microscopic confirmation is required. It is monoicous and sporophytes are common. Asexual propagules are unknown and it behaves as a colonist.

It grows on bare, open, sandy or loamy stony soils where there is little or no competition from other plants. Typically it occurs on soil ledges and in crevices on crumbling sunny, south-facing coastal cliffs, in old quarries, on roadside banks and Cornish 'hedges' (past reports of *T. cuneifolia* on fallow land are probably errors).

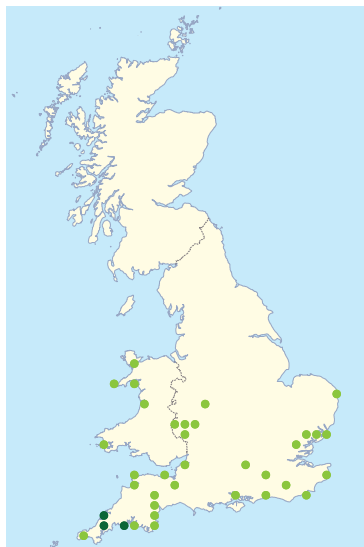
A member of the Mediterranean–Atlantic element, it is widespread in the southern European countries extending N to Ireland, Belgium, Germany and Hungary and E to Turkey. Elsewhere it is known from Syria, Lebanon and Israel, N Africa, Macaronesia, C Asia and Arctic Canada. In the BI it is known from Ireland, Wales (no records later than 1993) and England. The historical status of this moss in England is somewhat ambiguous; Braithwaite (1887)



LEFT: A close-up of *Tortula cuneifolia* showing the leaves widest above mid-leaf with a nerve ending in a hair-point. Photo: Des Callaghan. RIGHT: The erect, cylindrical capsule of *Tortula cuneifolia* with the calyptra still in place. Photo: Des Callaghan.

describes the plant as frequent in Devon and Cornwall and in H.N.Dixon's *Handbook* (1954) it is said to be not uncommon on the S coast, whereas J.A.Paton concluded that the evidence does not support such claims and in Cornwall describes it as very local (Paton, 1969). It has been recorded in a total of 43 10km squares in 17 English vice-counties, but post-1979 had declined to eight.

One of the earliest records is from E Cornwall collected by the Revd. J.S.Tozer (1790–1836) in 1821 from a roadside bank between Torpoint and St John. For well over a century records steadily accumulated, but then a long-term decline set in and from 1960 onwards it was known to survive in only six vice-counties, all in SW England. It disappeared from inland sites and the coastal occurrences contracted. It was last recorded in Somerset in 1965 by J. Appleyard (1906–1989) and in Devon in 1997 by G.P.Rothero and R.D.Porley growing on a sea cliff at Mouthstone Point near Noss Mayo. From 2000 it has been seen only in Cornwall at three localities (near Talland Bay, Malpas and Dennis Hill) in three 10km squares. Furthermore, all remaining populations are considered to be small and a search in 2012 of the well-known locality at Malpas (known as Sunny Corner), where it has been known since Tozer collected it in 1830, and was last seen in 2004, proved unsuccessful.



Tortula cuneifolia

The reasons for its decline are not well understood, although loss of open ground as a result of lack of grazing, nutrient enrichment and ammonia deposition may all play a role. Given the pattern of range contraction seen in *T. cuneifolia*, climate change may also be a factor even though it is a Mediterranean–Atlantic species. The plant occurs on one SSSI, Talland Barton Farm, otherwise there is no specific conservation action and the UK BAP is yet to be published. Priority actions should include ensuring extant sites are managed appropriately and carrying out targeted surveys at historic and potential new sites. Incorporation of material into the *ex situ* threatened bryophyte facility at RBGK should also be considered. In recognition of its continuing decline and persistence in small populations at less than five locations, the status of *T. cuneifolia* has been upgraded from Vulnerable (Church *et al.*, 2001) to Endangered on the revised British Red List.

M

POTTIALES

Tortula solmsii

Solm's Screw-moss

VU

NR

Upgraded

This moss, named after the German botanist H.Solms-Laubach (1842–1915), is a small yellowish-green tuft-forming acrocarp with shoots up to 2.5 mm tall, usually less. The leaves are somewhat twisted when dry and spreading when moist, widest above the middle with a nerve that ends immediately below, or slightly projects beyond, the rounded leaf tip. It is

dioicous and capsules are occasionally produced. Vegetative propagules are unknown and it behaves as a colonist.

It is a coastal plant growing on neutral to slightly basic soils, on low sandstone cliffs, moist roadside banks and on thin soil in crevices of granite walls, usually in well-lit situations but it is tolerant of some shade. Generally it grows in pure patches but *T. muralis* has been recorded as a close associate.

A member of the Mediterranean–Atlantic element, it is common in the Canary Islands, Madeira and the Azores. It is listed as rare in Europe (ECCB, 1995) and occurs on the Atlantic seaboard of Spain and Portugal and at scattered localities around the Mediterranean region E to Albania. Elsewhere it is known from Turkey, Algeria and Morocco. The plant reaches its northernmost stations on the southern coast of England. The first English collection was made in 1956 by J. Appleyard (1906–1989), from New Red Sandstone cliffs on the Otter Estuary near Budleigh Salterton in S Devon, but its identity was uncertain. In 1979, D. G. Long and J. A. Paton collected a small *Tortula* from crevices in an old wall on sea cliffs at Porthmoina Cove near Zennor, and realized it was the same as the Budleigh Salterton plant. It remained a puzzle until M. O. Hill solved the mystery: it turned out to be *T. solmsii* (Long & Hill, 1982), new to Britain. In 1984, it was found on sandy cliffs on both St Mary's and St Martin's, IoS, by DGL and JAP, and, in 1987, P. H. Pitkin and A. R. Perry found it on a roadside bank near the New Inn on Tresco, IoS.

Alarm bells rang in 1980 when a search of the Budleigh Salterton locality failed to detect any sign of it; so with some apprehension T. D. V. Swinscow (1917–1992) visited the site in 1982, this time with better luck. It occupied about one square metre of friable cliff face, in addition to a few smaller colonies, mixed with the green filamentous algae *Rhizoclonium riparium* (Swinscow, 1984). It was revisited ten years later by R. D. Porley and P. Martin in 1992. The population described by TDVS could not be re-found, but another colony was discovered on sandy cliffs to the N and S of a channel leading from South Farm, a locality



Tortula solmsii, showing the leaves widest above mid-leaf and a nerve ending in a pointed leaf tip.

Photo: Des Callaghan.



Tortula solmsii

just outside the Otter Estuary SSSI. At one spot, on the S side of the channel, it was growing in a large pure colony occupying an area some 4 m long by 25 cm wide, together with a few scattered patches along the sandy cliff towards the estuary mouth.

In Cornwall, there are two recent records: in 1998 SE of Cape Cornwall on soil crevices in an old wall on a sea cliff, and in 2010 at Porthmoina Cove (within the Aire Point to Carrick Du SSSI), where a small patch about 5 × 1 cm was found. In 2003, D. T. Holyoak and JAP found the plant at several localities on sea cliffs during a visit to IoS (Paton & Holyoak, 2005) within the Plains and Great Bay (St Martin's) SSSI and the Isles of Scilly Complex SAC, confirming the IoS as its English stronghold. However, it is not a listed feature on the SSSI notification and is not on the UK BAP. It may benefit from milder winters and drier summers, but rising sea levels and a greater incidence of coastal storms may reduce the available habitat and threaten some populations. The very small range, and its decline, has resulted in *T. solmsii* being upgraded from Near Threatened (Lower Risk) in the RDB (Church *et al.*, 2001) to Vulnerable on the revised British Red List.

M

POTTIALES

Tortula vahliana

Chalk Screw-moss

VU

BAP; NR

Upgraded

This moss is a small bright green acrocarp forming pure turfs or scattered shoots no more than 5 mm tall. Typically it has spoon-shaped leaves, widest above the middle, and a nerve that extends beyond the rounded leaf tip as a short greenish hair point. It is monoicous and sporophytes are frequent but very few appear to reach maturity in Britain possibly due to late spring frosts. Asexual propagules in the form of protonemal gemmae have been reported (Whitehouse, 1987) and irregular shaped rhizoidal tubers are known from Belgium (Andriesson *et al.*, 2002). It is a pioneer colonist.

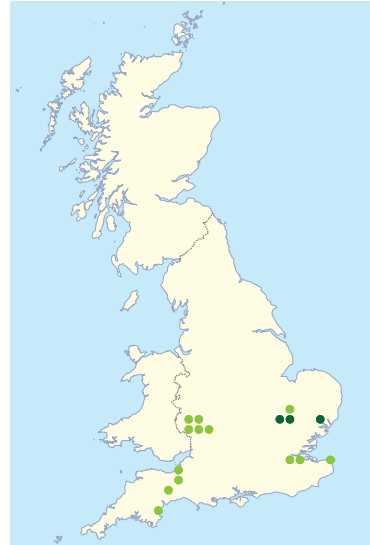
It grows on deeply shaded chalky clay banks along roadsides, in road cuttings and disused chalk pits on steep or sometimes vertical faces. Very rarely does it occur on other limestone. It is often found under scrub including Elder and brambles and on soil amongst tree roots, and has occasionally been noted on shaded soil around Badger setts. It is thought to have been over-recorded in the past due to confusion with the closely related *T. muralis* growing on soil.

A member of the Mediterranean–Atlantic element, *T. vahliana* has a scattered distribution in the Iberian Peninsula, France, Germany and Italy, the Mediterranean islands, Serbia and Greece. It is listed as rare on the European Red List (ECCB, 1995). Elsewhere it is reported from Turkey, N Africa, the Canary Islands and S America (Peru). It reaches its northern most stations in the BI, with old records from Ireland (extinct) and England. The first English record, in 1882, was collected by a youthful H. N. Dixon (1861–1944) at Cherry Hinton in Cambridgeshire. Indeed, he regarded this event as his ‘guiding star’ that was eventually to lead him onto the path of bryological eminence. HND shared his discovery of *T. vahliana* new to Britain with the leading 19th century bryologist and mentor R. Braithwaite (1824–1917), whose warm and genial encouragement saved him from ‘succumbing’ in his early forays into bryology.

It has been recorded from eight English counties (11 vice-counties), but disappeared in the early 1900s from W Kent, Gloucestershire and Herefordshire, from N Essex in 1960 and



A turf of *Tortula vahliana* showing the leaves widest above mid-leaf and a nerve ending in a shortly pointed leaf tip. Photo: Michael Lüth (Germany).



Tortula vahliana

Devon in 1974. The decline of *T. vahliana* is striking: post-1990 it has been recorded from S Somerset and E Kent, but only in E Suffolk (two sites) and its stronghold of Cambridgeshire, known from about ten localities, are there any post-2000 records. The ‘classic’ site is Cherry Hinton chalk pit. Since the late 1800s the pit has attracted a succession of bryologists, particularly members of the Cambridge Bryological Excursion group in the last few decades. Active quarrying slowed, ceasing altogether in the early 1980s, and rarities that needed open ground declined, including *Pterygoneurum lamellatum* (see page 204). However, *T. vahliana* survived, its requirement for shelter and shade provided by the encroachment of scrub. Amongst those who have followed the changes in the bryophyte flora of Cherry Hinton is H. L. K. Whitehouse (1917–2000), and *T. vahliana* has been affectionately referred to as one his ‘pets’; together with C. D. Preston, he has done much to clarify our understanding of this species in Britain.

Under favourable conditions this moss can clearly persist in an area over long time periods; it has been known for nearly 130 years at Cherry Hinton, and since 1985 at Bassingbourn chalk pit, Cambridgeshire, where, despite being on the menu of chironomid fly larvae (Davidson, Harborne & Longton, 1990), it was still present in 2007. It probably benefited from the regular use of ancient highways and byways as trampling helps to maintain bare ground, but the loss of hedgerows may also be a factor in its decline (Birks, 1974). Added to the UK BAP in 2007, an Action Plan has yet to be published. It is known to occur in only one SSSI, Cherry Hinton Pit. It seems to be absent from apparently suitable areas making this pioneer species a difficult one to conserve. It has been moved from Lower Risk (Near Threatened) in the RDB (Church *et al.*, 2001) to Vulnerable on the revised British Red List in recognition of the restriction to ten or fewer locations and its continued marked decline.

*Tortula wilsonii***Wilson's Pottia**

VU

BAP; NS

Downgraded

This moss, named in honour of the acclaimed bryologist W. Wilson (1799–1871) who first found it, is a small, bright or pale green acrocarp forming low turfs or solitary shoots less than 5 mm tall. The oval leaves, widest just above the middle, have recurved margins and a nerve that runs beyond the gradually tapering leaf apex to form a short hair point. Recently transferred from the genus *Pottia* into *Tortula* (meaning spirally twisted peristome teeth), it is superficially similar to several other 'pottioid' species and it can be difficult to identify in the field. It is monoicous and sporophytes are common. Specialized propagules are unknown. It shows an annual shuttle life-history, channelling resources into spore production with the leafy plant withering away during the long dry summer.

It is predominantly a coastal plant that grows on thin soil on rocky cliffs, landslips and under-cliffs, path and track sides, wall tops and on earthy hedgerows and Cornish 'hedges', occurring over both acid and basic bedrock. It is tolerant of extreme conditions such as nutrient poor drought-prone thin soils and salt-laden winds. It grows alongside a range of other coastal mosses with similar life-history strategies such as *T. atrovirens* and *T. viridifolia*.

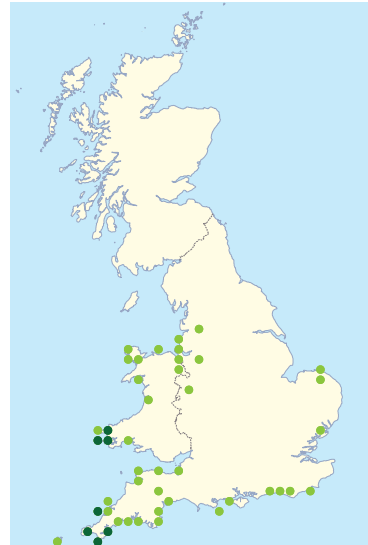
A member of the Mediterranean–Atlantic element, it has a distribution centred on the Atlantic seaboard of Europe from the BI to Spain, Portugal and the Mediterranean basin. Elsewhere it is known from N Africa and SW Asia. In the BI it is known from Ireland (extinct), Wales and England. The first English record belongs to Wilson dated 1882. He gathered it from a sandy hedge bank between Over and Delamere in Cheshire (one of its few inland stations). Convinced that it was sufficiently distinct from other closely allied plants, he sent specimens, notes and illustrations to Sir W. Hooker (1785–1865), botanist and first Director of RBGK, who was initially sceptical of Wilson's claims. Fortunately Wilson's tenacity paid off and Hooker named the new species in his honour.

This species has apparently undergone a precipitous decline for reasons that are obscure. In Britain it occurred in 50 10 km squares before 1980, but post-1980 it is known from just seven. Nonetheless, it remains listed as Nationally Scarce based on a cut-



Tortula wilsonii is tolerant of the extreme weather conditions found along some English coastlines.

Photo: Des Callaghan.



Tortula wilsonii

off date of 1950 onwards (Preston, 2006). It once extended from the N Norfolk coast around to S Lancashire but has retreated to the extreme SW of England and Wales. It has apparently disappeared completely from its inland sites. The last record in Somerset was 1990 (Brean Down SSSI), in Dorset 1977 (S Dorset Coast SSSI) and in Hampshire 1974 (Hurst Castle to Lymington River Estuary SSSI). Post-2000 records from W Cornwall occur on five SSSIs: Caerthillian to Kennack, Kennack to Coverack, West Lizard, Pentire Peninsula and Talland Barton Farm; all except the last two are within the Lizard SAC. A small quantity of this moss was also found in N Devon in 2012 by D. A. Callaghan along a cliff top at Hartland Quay in Marsland to Clovelly Coast SSSI (the record is too recent to be shown as a dark green dot on the map). It was added to the UK BAP list in 2007 but there is no specific conservation action. A survey of historic and potential coastal sites in England is a priority (it may be overlooked), and it should be included in the *ex situ* threatened bryophyte facility at RBGK. Scrub encroachment due to lack of grazing, nitrogen deposition, competition from invasive vascular plants and climate change may all be factors implicated in its decline. New records from the mid-2000s onwards from Cornwall and Pembrokeshire have resulted in the species being downgraded from its previous listing of Endangered (Church *et al.*, 2001) to Vulnerable on the revised British Red List.

M

POTTIALES

Weissia levieri

Levier's Beardless-moss

EN

BAP; NR

No change

Named in honour of the Swiss botanist Emile Levier (1839–1911), this moss is a small, dull green turf-forming acrocarp no more than 10mm tall, often less. The nerved leaves are strongly curled when dry and spreading when moist, gradually increasing in size up the stem and are flat (plane) to slightly incurved in their upper part. The plant is monoicous and sporophytes are common. The capsule is on a short seta and partially hidden amongst the uppermost leaves; uniquely within the subgenus (*Astomum*) it has a deciduous lid providing a useful field character, but microscopic confirmation is needed. Specialized asexual propagules are unknown and it behaves as a short-lived shuttle species, characterized by relatively large spores.

It is an ephemeral plant of thin, dry calcareous soils overlying limestone, typically on sunny south-facing slopes. It grows in open turf on cliff tops by the sea, on rocky ground and in rock crevices on coastal headlands. Intolerant of competition, the plant has few close associates although it sometimes grows with other *Weissia* species.

A member of the Mediterranean–Atlantic element, it occurs predominately in the Mediterranean region with very few records from C and W Europe; it is listed as rare throughout Europe (ECCB, 1995). Elsewhere it is known from N Africa. In the BI it is known from Wales (on the S coast) and England. Its distribution in southern England mirrors that of several other rare plants including the Red Listed moss *Cheilothela chloropus* (page 79) and the flowering plants White Rock-rose and Honewort. It has been found at three localities in Somerset and Devon, all on sunny, hard limestone. The first English collection was made during a 1959 BBS meeting at Brean Down SSSI/SAC, Somerset and was published new to the BI (Warburg, 1960); it was re-found here in 2011 by the Wessex Bryology Group. In 1997, D. T. Holyoak found it at a second Somerset locality at Middle Hope SSSI on a sunny south-



LEFT: *Weissia levieri* with immersed capsules; when mature the lid of the capsule falls away and the spores are released. Photo: Barry Stewart (Wales).



Weissia levieri

facing slope (still present in 2012, the largest colony about 100 cm²), and in 1999 at Petit Tor Point, near Torquay, new to Devon, within Babbacombe Cliffs SSSI.

Recently added to the UK BAP list, there is currently no published Action Plan and no specific conservation measures for this species. Habitat management is the key to its conservation, in particular grazing to maintain short, open turf; feral goats have been successfully employed at Brean Down SSSI. Regular surveillance of known sites is a priority to check that the habitat is adequately grazed and the species should be searched for at least once every three years. Axenic cultures sourced from Wales are held in the *ex situ* threatened bryophyte facility at RBGK. There have been very few collections or records of this Nationally Rare plant over the years, partly due to its ephemeral and scattered nature, but it may also be overlooked for other *Weissia* species, particularly when lacking capsules. It is arguable whether the plant has declined and it may benefit from climate change, but given the very restricted range and small number of populations, *W. levieri* is classified as Endangered on the revised British Red List.

M

POTTIALES

Weissia multicapsularis

Many-fruited Beardless-moss

CR

BAP; NR

Upgraded

This moss is a yellowish-green tuft-forming acrocarp up to 15 mm tall. The genus *Weissia*, named after the German botanist F.W. Weiss (1744–1826), is distinctive but naming to species level is not always easy. Recent studies using molecular markers (a gene or DNA sequence with a known location on a chromosome) support the view that *W. multicapsularis* is a good species (Conyers, Conyers & Laybourn, 2012). The leaves are flat (plane) or only

very weakly incurved in their upper part, with an abrupt transition between the short lower leaves and longer uppermost leaves. It is monoicous and sporophytes are common. The capsule, held on a short seta, is cleistocarpous, which means there is no lid to fall away; instead the capsule wall ruptures to release spores (contrast with the Red Listed *W. levieri* (page 191)). The name *multicapsularis* is misleading as this species normally has one capsule per shoot. Specialized asexual propagules are unknown and the life-history strategy shows elements of a colonist.

It is a coastal plant of bare ground on free-draining, nutrient poor, summer-droughted, neutral loamy soils, growing in sparse turf near the sea and on the earth capping of Cornish 'hedges'. In the past it was recorded from woodland rides, fields and brick-pits. It is a good example of a rare species that shows a narrow geographical range with small populations occupying low habitat specificity (Longton & Hedderson, 2000).

A European endemic, this plant belongs to the Oceanic–Temperate element and is globally rare. It was added to the IUCN World Red List as Critically Endangered in 2008, one of four British bryophytes on the list. It is classified as endangered in the European Red Data book (ECCB, 1995). Outside Britain it has been recorded from W France (not seen since 1972) and has been reported from Romania (Ștefănuț & Goia, 2012). In the BI it is known from Wales (Monmouthshire, 1980, re-found post-2000 by S. D. S. Bosanquet) and England. The first English record, in 1836, was made by the leading bryologist of the time W. Wilson (1799–1871) from one of its more northerly stations, Appleton in Cheshire. The second English record, by G. E. Hunt in 1870, also occurred in Cheshire. All subsequent records are from southern England. It has been recorded in a total of eight English vice-counties from about 25 localities, although 12 of the 16 records since 1950 are from Cornwall.

By the early 1990s it was clear that the plant had undergone a precipitous decline in England, and consequently was in the first tranche of bryophytes to have a published Action Plan under the UK BAP (1995). Funded by EN's Species Recovery Programme, D. T. Holyoak surveyed the historic Cornish sites and in 1998–9 re-found it at just three localities. All three populations are apparently relicts known since the 1960s. Two populations on the S Cornish coast are within SSSIs: Carricknath Point to Porthbean Beach SSSI, and



LEFT: A close-up of *Weissia multicapsularis* with immersed capsules that simply burst apart to release the spores. Photo: Des Callaghan. RIGHT: The habitat of *Weissia multicapsularis*, on free-draining, nutrient poor, summer-scorched soils amongst sparse turf near the sea. Photo: David Holyoak.

another that was designated in 2009 primarily to protect *W. multcapsularis* (the SSSI name is withheld to preserve its anonymity). The third locality, Pentire Point East, is not designated. Only a single fruiting plant was found on the recently designated SSSI in 2011, and a check in 2012 failed to detect any individuals although the habitat was in good condition.. A small population was seen at Carricknath Point to Porthbean Beach SSSI in 2010, and four new colonies were discovered by D.A.Callaghan in 2012 at Pentire Point East. Based on molecular marker analysis, the gene sequence of populations was found to differ very slightly between the two English SSSIs by a unique base pair, but the population in the recently designated SSSI matched the gene sequence from a Welsh population. The population at Carricknath Point to Porthbean Beach SSSI shared the unique base pair with *W. longifolia*, suggesting a common ancestry (Conyers, Conyers & Laybourn, 2012). These enigmatic results highlight the importance of conserving genetic diversity.



Weissia multcapsularis

The decline of this moss is thought to be related to agricultural intensification (it may benefit from the HAP for Arable Field Margins) and nutrient enrichment of soils; it does not tolerate competition. In the past, sheep grazing created extensive suitable habitat but such management has diminished, particularly on marginal cliff-top coastal sites, where rabbits are often now the only herbivores. Ponies that have been introduced to one SSSI are creating scuffed open turf, ideal for *Weissia*. Maintenance of colonies on Cornish hedges has been achieved by herbicide (Glyphosate) treatment and hand removal of competing vegetation. Material in axenic culture is held in the *ex situ* threatened bryophyte facility at RBGK, but cryopreservation should be considered for the long-term conservation of germplasm.

Given the extremely restricted area of occupancy and extent, together with the very small population and a marked decline in both the moss and its habitat quality, *W. multcapsularis* has been upgraded from Endangered (Church *et al.*, 2001) to Critically Endangered on the revised British Red List.

M

ORTHOTRICHALES

Zygodon forsteri

Knothole Yoke-moss

VU

BAP; WCA; NR

No change

Named after the botanist and plant illustrator T.F.Forster (1761–1825), this moss is an acrocarp that forms small, dark green to blackish cushions with shoots to 5 mm tall. The narrowly ovate leaves, slightly twisted when dry and spreading when moist, have plane untoothed margins and a nerve that extends beyond the tip in a short point. It is monoicous and sporophytes are common. Asexual propagules (gemmae) are formed on the protonema

enabling short-distance dispersal on the same tree and perhaps between trees (Adams & Rumsey, 2005); leaf fragmentation may also aid spread. It behaves as a colonist.

It grows on Beech maidens and pollards in old growth pasture-woodland, more rarely on oak, Field Maple and birch. It colonizes rain-tracks where water washes down the trunk from an overhead reservoir, knot holes, and depressions on exposed roots often some distance from the parent tree. It is an example of a species with a wide geographical range occurring in small populations occupying a narrow niche (Longton & Hedderson, 2000).

A member of the Suboceanic Southern-temperate element, it is known from several southern European countries extending N to Denmark and is listed as vulnerable in Europe (ECCB, 1995). Elsewhere it is known from Madeira and N Africa. In the BI it is confined to England. The earliest English record, attributed to T.F. Forster, was collected from a tree trunk in a Walthamstow timber yard *ca.* 1790, new to science. Not until almost 100 years later did E. M. Holmes (1843–1930) trace the tree back to Epping Forest in Essex. In 1882, he duly found the moss in Epping Forest during an Essex Field Club meeting “*on the root of an old tree, where water collects in little depressions*” and by 1912 it was known on a total of six trees. There were no more records after 1928, until K. Adams rediscovered it in an area known as Goldings Hill in 1978.

Meanwhile, in 1902 W.E. Nicholson (1866–1945) discovered it on Beech trees at Burnham Beeches, Buckinghamshire, and continued to record it up to 1905. B. O’Shea re-found it in 1966 during a London Natural History Society meeting (Little, 1967). The third modern locality was discovered in 1954 by M.C.F. Proctor on a Beech tree near Rufus



ABOVE LEFT: *Zygodon forsteri* cushion with capsules in root callus on Beech in Burnham Beeches, Buckinghamshire/Berkshire.

Photo: Ron Porley. ABOVE RIGHT: The shiny green leaves of *Zygodon forsteri* with protonemal gemmae visible to the right of the picture. Photo: Des Callaghan.

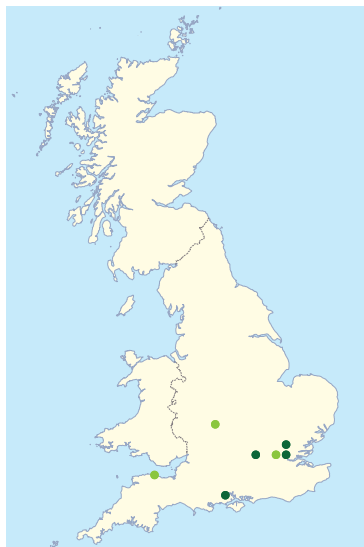
LEFT: Small tufts of *Zygodon forsteri* vie for space amongst *Hypnum cupressiforme* on root calluses of a Beech tree in Burnham Beeches, Buckinghamshire/Berkshire.

Photo: Ron Porley.

Stone in the New Forest. Other early records hint at a once wider distribution: on a rotten gatepost at Minehead in S Somerset in 1877 by Miss I. Gifford (1823?–1891), and on a Field Maple at Cleeve Hill in Worcestershire by H. H. Knight (1862–1944) in 1905–1910. In 1906, E. M. Holmes reported it near Studland in Dorset; unfortunately the record was not corroborated by a specimen and therefore cannot be accepted even though Holmes was familiar with the plant.

A UK BAP was published in 1998 but conservation foundations began to be laid much earlier. In 1978, KA rashly offered a £5 incentive to family members to find new colonies at Epping; ten years later it was estimated to occur on 20–30 trees and the reward for finding it suddenly deflated to 50p (Adams, 1984). In 2003–4 the City of London Corporation commissioned KA and F.J. Rumsey to assess the status in Epping Forest; in 2008 KA repeated the survey and established a monitoring protocol. Each colony, on some 76 trees in two hectads, was photographed, sketched, positioned by laser rangefinder triangulation and mapped using software that hyperlinks close-up images with the aim of displaying the data on a hand-held computer in the field (Adams, 2009). Parallel to this project, FJR (NHM) with support from the City of London Corporation and working with R. D. Porley (EN/NE) mapped, photographed and marked the colonies with electronic chips at Burnham Beeches. It was recorded on 78 trees in one hectad over the period 2004–2008; however a sample survey by FJR in 2010 indicated a 55% decline as well as a reduction in abundance (due in part to tree surgery operations). The status in the New Forest is also better understood through the efforts of local naturalist N. Sanderson; it is known from nine ancient old-growth pasture woodland compartments scattered over four hectads on at least 11 trees; most colonies are associated with rain-tracks on naturally damaged maidens.

The moss is fully protected under the WCA 1981, all three sites are designated as SSSI/SACs and axenic cultures are held in the *ex situ* threatened bryophyte facility at RBGK. Populations fluctuate depending on weather conditions, predation of capsules by slugs and competition from other bryophytes, but overall the plant is in decline (Adams & Rumsey, 2005). Its fidelity for veteran Beech trees is its Achilles heel: the sensitivity of Beech to drought is of great concern since climate change is likely to mean more summers with lower rainfall and higher incidences of drought (Porley & Hodgetts, 2005), not to mention storms that topple veteran trees. At Burnham, *Z. forsteri* is strongly associated with pollards but they are dying in large numbers due to old age exacerbated by the drought of 1976 followed by a succession of dry summers (there is a programme of replanting and pollarding but it may be too late). At Epping it is also largely associated with ancient Beech pollards. Given that *Z. forsteri* is restricted to three locations, and that the habitat quality and sub-populations are in decline, it is classified as Endangered on the revised British Red List.



Zygodon forsteri

Zygodon gracilis

Slender Yoke-moss

EN

BAP; WCA; NR

No change

This is a golden-brown, turf-forming acrocarp with shoots 2–6 cm tall, much larger than other members of the genus. The narrow leaves are sharply toothed at the tip, twisted when dry and recurved when moist. It is dioicous and sporophytes are very rare. Specialized asexual propagules are unknown in nature, although protonemal gemmae have been observed in culture. It is said to be a colonist.

It grows on Carboniferous limestone dry-stone walls at 270–520 m a.s.l., mostly on N- or NW-facing aspects where colonies intercept mist and rain; more rarely, it grows on natural rock outcrops (in contrast to the situation in central Europe). It typically grows as pure cushions but associates include *Z. viridissimus*, *Neckera crispa*, *Tortella tortuosa* and *Hypnum cupressiforme* var. *lacunosum*. It is an example of a species showing a narrow geographical range with a large population size occupying high habitat specificity (Longton & Hedderson, 2000).

A member of the European Temperate element, it is known from the Alps and Carpathians and is listed as vulnerable in Europe (ECCB, 1995). Elsewhere it is known from N America (British Columbia) and C America (Guatemala). The first English record, made in 1865, was by J. Nowell (1802–67) near Malham Tarn. He sent it to W. Wilson (1799–1871) who published it new to science in 1861 as *Z. gracilis*. However, in 1866, Nowell sent material to the German bryologist W. P. Schimper (1808–1880) who at the time was working independently on a European flora. Unaware of Wilson's publication, he named it *Z. nowellii* and published it in *Bryologia Europaea* 1876. Under international rules of botanical nomenclature, the first validly published name takes precedent.

During the late 1800s to early 1900s more localities were discovered, but by the mid-1900s new records had tailed off. It has been recorded from five distinct areas: Malham Tarn, Heselden Gill, Ingleborough, Moughton Fell and Horton-in-Ribblesdale (Shaw, 1962) in a total of five 10 km squares. It was added to the UK BAP in 1997 and the priority was to



ABOVE: A dense cushion of *Zygodon gracilis* on dry-stone walls near Pen-y-ghent, North Yorkshire. Photo: Ron Porley.

ABOVE RIGHT: A close-up of *Zygodon gracilis* showing the toothed leaf tip. Photo: Des Callaghan. RIGHT: Dry-stone walls at Giant's Grave, Cumbria, the locus classicus for *Zygodon gracilis*. Photo: Ron Porley.



assess its current status and distribution. During 2002/3, A. Headley and F. J. Rumsey surveyed over 40 km of dry-stone wall using a GPS and a laser Geodimeter to pin-point each cushion. It was present at Giant's Grave, Pen-y-ghent Gill and a wall below Pen-y-ghent, Dawson Close, Hesleden Gill, Middle House and Trow Ghyll; it was not re-found at five of the historical localities, including Moughton Fell and the Clapham area. Today *Z. gracilis* is virtually confined to a single hectad in the Pen-y-ghent area within Yorkshire Dales NP, and only three male cushions were seen in the Malham area (Middle House) in a second hectad, a significant contraction of its former range.

Headley and Rumsey (2003) also investigated the distribution of male and female colonies. They found a male: female sex ratio of 1:6.4 and a spatial segregation of the sexes with males restricted to the Pen-y-ghent area and at Middle House. Male and female plants are simply too far apart for fertilization to occur. Sporophytes are very rare in *Z. gracilis* and had only been found once in Britain, by Nowell in 1866, at Hesleden Gill where four young capsules and a few old ones were seen. Nowell said in a letter to Wilson “*perhaps I might have found more, but the day turned out very wet and was forced to leave the place.*” However, during their 2002/3 survey, AH and FJR made the thrilling discovery of young capsules on a cushion comprising male and female shoots. A search of the surrounding area near Pen-y-ghent did not reveal any more capsules, but they did find male and female cushions, some very large, on stable scree at 520 m. The only other occurrence on ‘natural’ rock seen during the survey was at Moughton Fell. Of some concern is predation of the archegonia by mites; many female plants were affected and this may partly explain the low incidence of sporophytes (damaged archegonia has been noted on a specimen collected in 1867).



Zygodon gracilis

Populations at lower altitudes, between 260–400 m a.s.l., have endured the greatest losses. The altitude of extinct and extant populations is statistically significant, with extant populations occurring at higher elevations, suggesting climate change may be a factor. In the late 1800s the BI was emerging from the icy grip of the Little Ice Age, and the decline of *Z. gracilis* ensued for over 100 years, during which time the average winter temperature in Britain increased by 0.5°C. Any attempts to conserve or re-establish the species at lower altitudes may thus be doomed to failure.

It is fully protected under the WCA 1981 and, together, Pen-y-ghent SSSI and Pen-y-ghent Gill SSSI support most of the remaining English population. Threats include eutrophication resulting from intensive livestock farming, ammonia deposition, and maintenance of dry-stone walls including top-wiring using toxic zinc-coated wire. It is important that close liaison is maintained between landowners, NE and NP Staff. It is held in axenic culture in the *ex situ* threatened bryophyte facility at RBGK and translocation techniques are being trialled, with *Z. gracilis* protonemata weaned onto pieces of limestone (Duckett *et al.*, 2004) and transferred to the wild. Given that there has been a clear decline in area of occupancy and extent of occurrence, it is classified as Endangered on the revised British Red List.

Losses – the English extinctions

The loss of 30 bryophytes in England (four liverworts and 26 mosses) since records began represents about 3% of the total English bryophyte flora (based on 922 species). This rate of extinction is relatively low compared to other groups, such as butterflies (24% of native species lost in England), amphibians (22%) or stoneworts (14%), but it is close to vascular plant losses (2%) (NE, 2010). In addition, three mosses at the level of *variety* have disappeared.

Habitat loss and modification (for example due to nutrient enrichment) have been the primary drivers of localized plant loss and the decline of plant populations in England. A lack of management has also been a key factor that has affected species with specialized habitat niches. The most important predictors of which plant species will be lost, from lowland counties in particular, are rarity, their degree of habitat specialization and competitive ability (NE, 2010). Climate change may also have an impact, especially in the English uplands.

Extinctions and the Red List

The IUCN considers the Extinct categories as an integral part of a Red List, alongside Critically Endangered, Endangered and Vulnerable. The IUCN threat categories used throughout this book are fundamentally probabilistic assessments of the likelihood that species in a particular threat category will go extinct within some stated time (see section on the Red List, *page 31*); species of Lower Concern, for example, are not expected to go extinct in the near future. There are inherent time lags between changes on the ground and their detection and incorporation into the evaluation of a species status. Therefore focussing on extinctions should not be the driver for conservation action, it is the rate of decline of a species that is critical; the trend of many species is towards smaller populations and a decline in occupancy and range, rather than to extinction *per se*. Nevertheless, extinction is a key measure of biodiversity loss that has a resonance with both the public and policy makers.

There are two IUCN categories of extinction relevant to British bryophytes: Extinct (EX) (when there is no reasonable doubt that the last individual has died), and Regionally Extinct (RE) (if there are no post-1979 records in Britain and all known localities have been visited and surveyed without success). A third category, Extinct in the Wild (EW), is used for when a species is known to survive only in cultivation or as a naturalized population well outside the past range; there are no British species in this category. It is understandably less easy to be categorical about the extinction of something as small as a bryophyte compared to a large large animal or bird such as the Dodo (at a global scale the IUCN considers a lack of records for a 60-year period sufficient to declare a



Tetrodontium repandum, sadly extinct in England. Only ever found twice in Britain: at Ingleby Greenhow, Yorkshire, and at Uckfield, E Sussex, and never seen since.
Photo: Štěpán Koval (Czech Republic).

species extinct). It is, of course, possible that a bryophyte considered extinct in this country may turn up as a result of immigration of spores or other propagules (the ‘rescue effect’, see page 34) or simply because it was overlooked in the first place – this is one reason why Extinct species are retained on the Red List.

Two British bryophytes are considered globally Extinct of which one occurred in England. The moss *Weissia mittenii*, commemorating W. Mitten (1819–1906) who first collected it in 1845 at Hurstpierpoint in W Sussex, was known from a total of six sites in E Sussex and Surrey, and was last seen in 1920 by W. E. Nicholson (1866–1945). This English endemic is suspected of being of hybrid origin; although sporophytes were frequent, capsules were malformed and spores were abnormal (Hill *et al.*, 2006). The revised British Red List comprises a further 23 species that are considered Regionally Extinct, of which ten occurred in England (all are mosses apart from one liverwort *Fossombronia mittenii*). With the exception of *Bryum turbinatum*, *Bryum uliginosum* and *Pterygoneurum lamellatum* the English extinctions involve species that had very restricted ranges or were known from five or less localities.

The history of *Helodium blandowii* and *Paludella squarrosa* in England

Both *Helodium blandowii* and *Paludella squarrosa* have well documented histories in England. The former was discovered in 1831 by W. Wilson (1799–1871) on Knutsford Moor in Cheshire and subsequently found at three other sites in Yorkshire. Initially, Wilson mistook his Knutsford plant for *Abietinella abietina* (a very similar looking species) with sporophytes, but following correspondence with Sir W. Hooker (1785–1865) it became clear that it was *H. blandowii* and was new to Britain. In 1832, Wilson transplanted some fruiting *H. blandowii* to Risley Moss near Warrington (Cash, 1886) in what might be the earliest documented example of a translocation of a moss in England. Out of curiosity, J. Cash (1839–1909), first chairman of the Manchester Cryptogamic Society and a *Guardian* journalist, located the ‘low swampy spot near Oak Wood’ where Wilson had transplanted *H. blandowii* some 50 years earlier, only to find it drained and supporting a fine crop of potatoes. Today Risley



A glacial relict: *Helodium blandowii*, possibly the earliest documented translocation of a moss in England, albeit unsuccessful. Photo: Hans Øllgaard (Denmark).

Moss is an SSSI, and water levels have been raised in an attempt to restore this former cut-over bog.

A second translocation effort was attempted in the mid-1880s. Fearing the extirpation of *H. blandowii*, Cash, along with an anonymous friend, collected “a good handful of the moss” from Knutsford and planted it on Brookhouse Moss to the east of Sandbach, a “solitary waste, haunted only by wild fowl and under strict preservation.” They marked the spot with a wand from a neighbouring willow. The friend of Cash returned twelve months later and found *H. blandowii* “growing nicely and the wand itself – like Aaron’s rod – had taken root.” Today Brookhouse Moss is also an SSSI, notified as an outstanding example of a moss (an infilled basin by *Sphagnum* accumulation) at an advanced stage of development with fen woodland dominated by birch, Alder and willow – perhaps the legacy of the ‘wand’ that marked *H. blandowii*. There is no further record or indeed mention of the plant from Brookhouse Moss and it was last seen at Knutsford Moor or in the county no later than 1901.



The striking *Paludella squarrosa* with neatly ranked leaves, each one bent backwards (scurry). Photo: Biopix J.C. Schou (Denmark).

At about the same time that Wilson found *H. blandowii* at Knutsford Moor he discovered *Paludella squarrosa*, also new to Britain. Sub-fossil evidence shows that both species were once more widespread in Britain and are regarded as Pleistocene glacial relicts showing a contraction to Cheshire and Yorkshire at the Boreal–Atlantic transition about 5,000 years before present (Dickson, 1973). *P. squarrosa* was indeed a common moss in Britain, particularly in northern England, during the early Flandrian (the present interglacial period) and was a significant peat former. It was found again in 1842 by H. Ibbotson (1814–1886) at Terrington Carr in NE Yorkshire, a once botanically rich site in the Howardian Hills; two months later he returned, bringing along the naturalist-explorer R. Spruce (1817–1893) to show him the remarkable moss, which was growing in some abundance. However, following the wet summer of 1860, the Carr was drained and planted in part with spruce and Scots pine (Gulliver, 1990). The last record of *P. squarrosa*, supported by a voucher from Terrington Carr, is dated 1858 by G.E. Hunt (1841–1873), although the final obituary (in Baker, 1906) was given by M.B. Slater (1830–1918) and G. Stabler (1874–1965) who reported that when they visited in 1868 it was reduced to a few stems.

At Knutsford Moor *P. squarrosa* had been lost some two decades earlier, also as a result of drainage, and it seemed that it could no longer lay claim to be an extant British plant (Cash, 1886). Astonishingly, another population was discovered in 1916 on Skipwith Common in SE Yorkshire, found by J. Mennell (little biographical detail exists although he was a member of the MEC, the forerunner of the BBS). Nothing is known as to what became of the plant at Skipwith Common (the site today is an SSSI and a SAC supporting wet and dry heath and open water) and there are no further records from here or indeed England.

As glacial relicts, both *H. blandowii* and *P. squarrosa* were already in terminal decline in Britain, but it was the progressive erosion in botanical richness and habitat loss that were

commencing in a piecemeal fashion that prematurely pushed these plants over the edge. The good news is that *P. squarrosa* still endures in the British Isles; several small colonies were discovered in 1998 in a rich fen in Mayo, new to Ireland (Lockhart, 1999).

The long lost English species

The table *opposite* gives the species lost from England. It has been compiled from the revised British Red List (Hodgetts, 2011), the Census Catalogue (Hill *et al.*, 2008) and data from the NBN. The Census Catalogue distinguishes records that have not been seen since the beginning of 1960 (*i.e.* post-1959), thereby differing from the post-1979 cut-off date used in the revised British Red List. The English species with no post-1959 records extracted from the Census Catalogue are nevertheless present in Wales or Scotland or both. There are five species on the revised British Red List (*Cynodontium polycarpon*, *Eurhynchiastrum pulchellum*, *Grimmia anodon*, *Liochlaena lanceolata* and *Seligeria diversifolia*) that have post-1959 English records in the Census Catalogue and therefore have full species profiles. Recent data (NBN) nevertheless suggests that they have vanished from England.

Apart from six species, it is remarkable that all the bryophytes considered to be extinct in England belong to major biome categories with predominately northern affinities (Hill & Preston, 1998), including Boreo-Arctic Montane, Boreal-montane and Arctic-montane biomes. Indeed, most of the species not seen in England for more than 50 years were formerly known from only a few localities mostly in the Lake District but also the Pennines and other upland areas. England is probably on the southern limits of their distribution range. Habitat loss and modification is most likely the principal reason for the losses, but it is tempting to speculate that climate change may also be playing a role by shifting suitable climate space further north (essentially into Scotland). Out of 30 species (excluding varieties) regarded as extinct in England, there are equal numbers of monoicous and dioecious species, and for 16 species sporophytes are unknown or very rare. Dispersal limitation is clearly a causal factor in rarity and ultimately extinction, particularly in dioecious species where sporophytes are unknown or very rare (11 species). In monoicous species, although sporophyte production is generally high, a narrow habitat specificity and habitat fragmentation (which acts as a dispersal barrier) probably in part explains their rarity. In terms of life strategies, ten of the species considered extinct are perennials and six are long-lived shuttles, groups that show low or moderate reproductive effort and are typically associated with permanent or semi-permanent habitats. Some 14 of these species belong to colonist, short-lived shuttle, annual shuttle and pioneer groups with typically high reproductive effort.



A specialist of mud-capped stone walls and other disturbed habitats, *Pterygoneurum lamellatum* has disappeared from England. A project has begun in the Cotswolds that aims to recreate the mud-capped wall niche.

Photo: Štěpán Koval.

Species not recorded in England since 1980

Compiled from: * British Red List (Hodgetts, 2011) † Census Catalogue (Hill *et al.*, 2008) ‡ NBN

Species (M = moss; L = liverwort)	Year of last English record	Possible reason(s) for loss
M <i>Aulacomnium turgidum</i> †	1930	Uncertain, possibly climatic factors
M <i>Bartramia stricta</i> †	1865	Over-collecting, habitat changes
M <i>Bryum cyclophyllum</i> †	1939	Water regime/quality changes
M <i>Bryum turbinatum</i> *	1947	Uncertain, possibly successional changes
M <i>Bryum uliginosum</i> *	1945	Uncertain, drainage partly responsible
M <i>Conostomum tetragonum</i> †	1954	Uncertain, possibly climatic factors
M <i>Cynodontium polycarpon</i> ‡	1963	Unknown
M <i>Dicranum elongatum</i> *	1869	Uncertain, possibly climatic factors
M <i>Didymodon icmadophilus</i> †	1959	Uncertain, possibly climatic factors
L <i>Diplophyllum taxifolium</i> †	1918	Uncertain, possibly climatic factors
M <i>Eurhynchiastrum pulchellum</i> ‡	1980	Land-use changes, neglect
L <i>Fossombronina mittenii</i> *	1972	Land-use changes
M <i>Grimmia anodon</i> ‡	1961	Over-collecting, possibly climatic factors
M <i>Gyroweisia reflexa</i> *	1938	Development (sandstone quarry habitat built over)
M <i>Helodium blandowii</i> *	1901	Drainage, loss of fen habitat, glacial relict
M <i>Herzogiella striatella</i> †	before 1908	Uncertain, possibly climatic factors
M <i>Kiaeria falcata</i> †	1950	Uncertain, possibly climatic factors
L <i>Lioclaena lanceolata</i> ‡	1966	Unknown
M <i>Paludella squarrosa</i> *	1916	Drainage, loss of fen habitat, glacial relict
M <i>Palustriella decipiens</i> †	1930	Uncertain, possibly climatic factors
M <i>Philonotis tomentella</i> †	1958	Uncertain, possibly climatic factors
M <i>Pseudoleskeella rupestris</i> †	1901	Uncertain, possibly climatic factors
M <i>Pterygoneurum lamellatum</i> *	1970	Succession, loss of open ground, loss of mud-capped walls
L <i>Scapania praetervisa</i> †	1952	Unknown
M <i>Schistidium frigidum</i> †	1886	Uncertain, possibly climatic factors
M <i>Seligeria diversifolia</i> ‡	1971	Uncertainty regarding identity
M <i>Sphagnum obtusum</i> *	1911	Drainage, loss of peat bogs
M <i>Sphagnum strictum</i> †	before 1900	Uncertain, habitat loss
M <i>Tetrodontium repandum</i> *	1958	Unknown (seen only once at each of its two localities)
M <i>Weissia mittenii</i> *	1920	Unknown, possibly a hybrid

The species that are not within northern biomes in the table above require another explanation for the losses. The Wide-temperate *Grimmia anodon* (page 109) is a strongly continental species and therefore marginal in the British Isles; over-collecting may have hastened its demise in England. The Circumpolar Southern-temperate *Pterygoneurum lamellatum* (page 202 and 205) had numerous localities in the mid-19th to early 20th century but the rather narrow ecological niche (including mud-capped stone walls and open calcareous ground, see Porley & Hodgetts, 2005), and its poor competitiveness probably contributed to its vulnerability. As land-use and management practices changed, coupled with increasing nutrient levels in the soil, its specialized niche disappeared and populations declined below threshold levels beyond which the moss could not recover.

Sphagnum strictum, a member of the Hyperoceanic Temperate element, is frequent in western Norway but otherwise rare in Europe, and shows a predominately pan-tropical distribution. In the British Isles it is decidedly northern in its distribution and phytogeographically is similar to the Oceanic Boreal-montane element; in England it was known from a single site in Langdale. *Bartramia stricta* (see pages 204–5 and Appendix 1), a member of the Mediterranean-Atlantic element, is common in the Mediterranean region but has always been a very rare plant in Britain, and today is known from one locality in Wales. The English locality, near Maresfield in Sussex, was discovered by G. Davies (1834–1892) in 1861 on calcareous sandstone; the last collection was made in 1865. Such a small, isolated population would have been vulnerable to habitat change and over-collecting. Finally, both *Fossombronia mittenii* and *Gyroweisia reflexa* belong to the Mediterranean-Atlantic element. The former, a liverwort known from just three or four localities in England, probably disappeared as a result of land-use changes and its inability to compete with taller flowering plants (Church *et al.*, 2001). The latter, a moss known from a single locality in Warwickshire, was lost to development (Church *et al.*, 2001).

The regions in which many of the ‘vanished’ species grow are amongst the most remote and mountainous in England. Recording activity in such areas is probably at a very low level and the chances of overlooking a species must be very high. Maybe it is not too surprising, therefore, that species not seen for many years such as the liverwort *Herbertus stramineus* and the mosses *Andreaea mutabilis*, *Rhytidiadelphus subpinnatus* and *Sphagnum platyphyllum* have recently been rediscovered in the English uplands. This suggests that if recording effort is focused on target areas, or on species, there will be a good chance of re-finding bryophytes regarded as ‘vanished’ in England.

Could the extinctions have been averted?

Whether any of the above extinctions were preventable is a moot question. It is arguable that the loss of some species is inevitable given the protracted history of habitat destruction, land-use changes, climate change and the impact of an increasing human population on these islands. Many of the losses occurred around the mid-20th century or earlier, well before there was any appreciation of bryophytes within the nascent conservation community or legal instruments aimed specifically at bryophytes – indeed such institutions and measures were far into the future.

Hints of an awareness of the threats that bryophytes contend with go back to at least the mid-19th century: the history of *Helodium blandowii* was mentioned earlier. W. Borrer (1781–1862) expressed alarm concerning the stripping of *Cyclodictyon laetevirens* (page 83) from its cave walls, and when Borrer was planning a bryological trip to Anglesey and Snowdonia he wrote to W. Wilson enquiring “whether you can give me such directions as may enable me to find readily some of the rarest plants, of which I engage to help myself so

moderately as not to endanger their exterminations.” Nevertheless, collecting was the foremost pursuit of natural historians, and so it continued largely unrestrained. Many years later H.N.Dixon voiced his concern over the aims of the MEC, a Club that reproached its membership for contributing less than copious gatherings of bryophytes. He feared it would lead to the extermination of rarer species. It is very likely that over-collecting did contribute to the demise of populations, at least at the local level.

The BBS formally abolished the exchange of bryophytes in 1970. Concern for bryophyte conservation continued to be articulated by individuals, but it was not until 1977 that the BBS appointed a Conservation Officer, P.D.Coker. One of the first tasks included compiling a list of 15 rare and endangered British bryophytes (compiled by the BBS in 1978) and in 1979 a Code of Conduct was published and distributed to members, field study centres and college botany departments. The SSSI network did not exist until the National Parks and Access to the Countryside Act 1949, and site selection criteria were initially pithy and little attention was given to bryophytes. Against this background, there was probably little prospect of preventing most or any of the earlier extinctions.

The moss *Pterygoneurum lamellatum* was known to be rapidly declining in Britain (it was placed on the preliminary list of rare and endangered bryophytes drawn up in 1978), and the last records were made in 1970 from Cherry Hinton Pit SSSI, Cambridgeshire (notified in 1951) and at East Wretham Heath, Norfolk, in 1967 (possibly just outside the SSSI, on bare ground by the roadside near Ringmere where it would have been much more difficult to conserve). For some time the Cambridgeshire Bryophyte Group was concerned about the deteriorating quality of Cherry Hinton Pit SSSI and the fate of *P. lamellatum* and other mosses. Despite representations to the NCC, and the fact that it occurred on a designated site that had been known for its rare plant interest for more than 300 years, invasive vegetation continued to encroach onto open ground and *P. lamellatum* disappeared. The moss *Eurhynchiastrium pulchellum* (page 104), last seen in 1980 on Lakenheath Warren SSSI in England, illustrates a similar story. Timely and appropriate management, adequately resourced, may have made a difference but clearly the mechanisms and processes for achieving bryophyte conservation had not yet attained maturity or efficacy.

Some may contend that conservation is still failing bryophytes. The national decline of *Atrichum angustatum* (page 56) had been apparent for many years, and the last known population in Sussex was recognized to be at a very high risk of extinction. Action to manage and designate the site did not receive the urgency and priority needed and the moss apparently vanished soon after 2000. There is, nevertheless, at least one success story: *Didymodon glaucus* (page 94) epitomises how, through direct conservation action, endangered bryophytes can be pulled back from the brink of extinction.



A common Mediterranean moss, *Bartramia stricta* disappeared from England in 1865.
Photo: Ron Porley (Portugal).

APPENDIX 1: British Red List species with post-2000 Welsh and Scottish records but not seen in England for over 50 years (Hill *et al.*, 2008).

BRYALES

Bartramia stricta Upright Apple-moss **CR** BAP; WCA; NR

This moss, an acrocarp forming tufts to 2 cm high, has already been mentioned on page 204. Herbarium specimens reveal it was collected by two bryologists, initially by G. Davies (1834-1892) in 1861 and in every subsequent year up to 1865. W. Mitten (1819-1906) also collected it in 1862. There is a 1965 record from Scotland but it has never been seen since, and only in Wales, at Stanner Rocks SSSI/NNR in Radnorshire are there post-2000 records. It occurs in the Channel Islands and is not uncommon in southern Europe; it has a wide African and Southern Hemisphere distribution. It is rare in N America, and the most northerly population (in British Columbia) is subject to a recovery programme. This Mediterranean-Atlantic species is on the northern limits of its range in England, but it is possible that over-collecting expedited its loss. Conservation action in Britain includes accession to the RBGK *ex situ* threatened bryophyte facility, where Welsh material is held in axenic culture and in cryopreservation.

BRYALES

Bryum cyclophyllum Round-leaved Bryum **EN** BAP; NR

This moss, with turf-forming often straggling shoots up to 8 cm long, is one of the most distinctive members of the genus characterized by almost round leaves. It grows on periodically inundated ground of lakes and reservoirs. This dioicous species has not been recorded with capsules in the BI but has filamentous gemmae in the leaf axils and is a short-lived shuttle species. The first English record is attributed by C.H. Binstead (1862-1941) in 1912 and the last record was made by U.K. Duncan (1910-1985) in 1939. It was restricted to the English Lake District, at Bassenthwaite Lake, Derwent Water and Grasmere. Only in Scotland are there post-2000 records, from two reservoirs near Edinburgh. This Boreal-montane species is not threatened in Europe and is also known from Asia and Greenland. Clearly on the southern limits of its range in England, its loss may also have been precipitated by changes in water-levels and over-growth by competing vegetation. There is no specific conservation action directed at this species.

JUNGGERMANIALES

Scapania praetervisa Ciliate Earwort **VU** NR

This leafy liverwort forms smooth mats or solitary shoots to 10 mm long; the leaves are complicate-bilobed (folded face to face with a keel) and oval shaped gemmae are produced on the margins of young leaves. It is dioicous and perianths are usually present but males are rare and sporophytes are unknown in Britain. It is a colonist, growing on moist soil on shaded limestone boulders and base-rich rock ledges by rivers and streams in wooded gorges and ravines; it belongs to the Boreo-Arctic Montane element, a group that is predominately calcicolous. It was discovered new to England by J. Appleyard (1906-1989) in 1952 at Thorne Gill in the Craven limestone district of Yorkshire but despite searches has not been seen since. There are two post-2000 records from Scotland. It occurs mostly in N and C Europe and is not threatened, and is also known from northern Asia and N America. The reasons for its apparent loss are unknown, although it may have been a victim of climate change. It is possible however that this inconspicuous plant is still present in England and it should be searched for.

APPENDIX 2: Species' Status Summary

This Appendix provides a summary of the sexuality (where known), IUCN British Red List category, floristic element, life-history, Nitrogen value, substrate class(es) and the Level 2 EUNIS (European Nature Information System) classification (see *page 37*) for all 87 English threatened species on the revised British Red List.

Key

MOSSES AND LIVERWORTS

M	Denotes mosses
L	Denotes liverworts

SEXUALITY

Mon.	= Monoicous
Dio.	= Dioicous

IUCN BRITISH RED LIST CATEGORY

CR	= Critically Endangered
EN	= Endangered
VU	= Vulnerable

FLORISTIC ELEMENTS *

- 16 Circumpolar Arctic–montane
- 23 European Wide–boreal
- 26 Circumpolar Boreo–Arctic Montane
- 42 Suboceanic Boreal–montane
- 43 European Boreal–montane
- 44 Eurosiberian Boreal–montane
- 45 Eurasian Boreal–montane
- 46 Circumpolar Boreal–montane
- 52 Suboceanic Boreo–temperate
- 53 European Boreo–temperate
- 55 Eurasian Boreo–temperate
- 56 Circumpolar Boreo–temperate
- 66 Circumpolar Wide–temperate
- 71 Oceanic Temperate
- 72 Suboceanic Temperate
- 73 European Temperate
- 74 Eurosiberian Temperate
- 75 Eurasian Temperate
- 76 Circumpolar Temperate
- 80 Hyperoceanic Southern–temperate
- 81 Oceanic Southern–temperate
- 82 Suboceanic Southern–temperate
- 83 European Southern–temperate
- 86 Circumpolar Southern–temperate
- 91 Mediterranean–Atlantic
- 92 Submediterranean–subatlantic

LIFE-HISTORY †

- AS Annual Shuttle
- LS Long-lived shuttle
- SS Short-lived shuttle
- C Colonist
- CP Colonist pioneer
- E Ephemeral
- PS Perennial stayer

NITROGEN VALUES *

- 1 Extremely infertile sites
- 2 Infertile sites
- 3 Moderately infertile sites
- 4 Between 3 & 5
- 5 Moderately fertile sites
- 6 Between 5 & 7
- 7 Richly fertile sites

SUBSTRATE CLASSES *

- SO Soil
- SR Soil on rock
- RH Rock, hard
- RS Rock, soft
- RWRock, worked
- PT Peat
- GS Gravel or sand
- DA Decaying animal
- DV Decaying vegetation
- BR Bryophyte
- EN epiphytic non-woody
- EW epiphytic living wood

HABITAT CLASSES *

- A2 Littoral sediment (saltmarsh)
- B1 Coastal dunes & sandy shores
- B3 Rock cliffs, ledges & shores
- C2 Surface running waters
- C3 Littoral zone inland surface waters
- D1 Raised & blanket bogs
- D2 Valley mires, poor fens
- D4 Base-rich fens
- E1 Dry grasslands
- E3 Seasonally wet & wet grasslands
- E7 Sparsely wooded grassland
- F3 Temperate scrub
- F4 Temperate shrub heathland
- F9 Riverine & fen scrubs
- FA Hedgerows
- G1 Broadleaved deciduous woodland
- G1R Rides in broadleaved woodland
- G3 Coniferous woodland
- H3 Inland cliffs, rock pavements and outcrops
- H5 Miscellaneous inland habitats with little or no vegetation
- I2 Cultivated parks & gardens
- J2 Low density buildings
- J3 Extractive industry sites

* after BRYOATT (2007)

† after Dierßen (2001)

Moss/Liverwort	Species/English name	Page	*Sexuality	IUCN British Red List category	Biodiversity Action Plan Wildlife & Countryside Act	*Floristic element	†Life-history	*Nitrogen value	*Substrate classes	*Level 2 EUNIS habitat classes
M	<i>Acaulon mediterraneum</i> Spiny-spored Pygmy-moss	46	Mon.	VU	–	91	AS	4	SR, SO	E1
M	<i>Acaulon triquetrum</i> Triangular Pygmy-moss	47	Mon.	EN	BAP/WCA	92	AS	2	SO	E1, H5
M	<i>Andreaea frigida</i> Icy Rock-moss	49	Mon.	VU	BAP	43	LS	1	RH	C3
M	<i>Anomodon attenuatus</i> Slender Tail-moss	51	Dio.	EN	–	56	PS	4	RH	G1, H3
M	<i>Anomodon longifolius</i> Long-leaved Tail-moss	52	Dio.	VU	BAP/WCA	55	PS	4	RH	G1, H3
M	<i>Aplodon wormskioldii</i> Carrion-moss	54	Mon.	CR	BAP	16	SS	2	DA	D1
M	<i>Atrichum angustatum</i> Lesser Smoothcap	56	Dio.	CR	BAP	73	SS	3	SO	G1R
M	<i>Bartramia stricta</i> Upright Apple-moss	206	Mon.	CR	BAP/WCA	91	LS	3	RH, RS, SR, SO	H3
M	<i>Bruchia vogesiaca</i> Vosges Candle-moss	58	Mon.	CR	–	72	SS	3	SO	H5
M	<i>Bryum calophyllum</i> Blunt Bryum	60	Mon.	VU	BAP	26	SS	4	GS	B1
M	<i>Bryum cyclophyllum</i> Round-leaved Bryum	206	Dio.	EN	BAP	46	SS	4	SO	C3
M	<i>Bryum gemmiparum</i> Welsh Thread-moss	61	Dio.	EN	BAP	91	C	4	RH	C3
M	<i>Bryum knowltonii</i> Knowlton's Thread-moss	63	Mon.	VU	BAP	43	SS	4	GS	B1
M	<i>Bryum marratii</i> Baltic Bryum	65	Mon.	VU	BAP	43	SS	4	SO, GS	A2, B1, C3
M	<i>Bryum salinum</i> Saltmarsh Thread-moss	67	Mon.	EN	BAP	23	SS	4	SO	A2, B1
L	<i>Cephaloziella baumgartneri</i> Chalk Threadwort	69	Mon.	EN	BAP	91	C	2	SR, RS	E1, H3, J3
L	<i>Cephaloziella dentata</i> Toothed Threadwort	70	Dio.	CR	BAP	81	C	2	SO	F4, H5
L	<i>Cephaloziella integerrima</i> Lobed Threadwort	72	Mon.	VU	BAP	42	C	1	SO	F4, H5, J3
L	<i>Cephaloziella massalongi</i> Lesser Copperwort	74	Dio.	VU	–	52	C	1	SR, SO, RH	J2, J3
L	<i>Cephaloziella nicholsonii</i> Greater Copperwort	75	Mon.	VU	BAP	71	C	1	SR, SO, RH	J2, J3
M	<i>Ceratodon conicus</i> Scarce Redshank	77	Dio.	CR	BAP	92	C	2	SR, SO	H5, J2, J3
M	<i>Cheilothea chloropus</i> Rabbit Moss	79	Dio.	VU	–	91	C	2	SO	E1

Moss/Liverwort	Species/English name	Page	*Sexuality	IUCN British Red List category	Biodiversity Action Plan Wildlife & Countryside Act	*Floristic element	+Life-history	*Nitrogen value	*Substrate classes	*Level 2 EUNIS habitat classes
M	<i>Cinclidotus riparius</i> Fountain Lattice-moss	81	Dio.	VU	–	74	PS	4	RH, RW	C3, H3, J2
M	<i>Cyclodictyon laetevirens</i> Bright Green Cave-moss	83	Mon.	EN	BAP/WCA	80	PS	3	RH	B3, H3
M	<i>Cynodontium polycarpon</i> Many-fruited Dog-tooth	85	Mon.	VU	–	43	C	1	RH	H2, H3
M	<i>Dialytrichia saxicola</i> Brittle Lattice-moss	87	Dio.	VU	–	91	C	5	RW, EW	C3, G1
M	<i>Dicranum spurium</i> Rusty Fork-moss	88	Dio.	VU	BAP	43	PS	2	SO	F4
M	<i>Dicranum undulatum</i> Waved Fork-moss	90	Dio.	VU	BAP	26	PS	1	PT	D1
M	<i>Didymodon cordatus</i> Cordate Beard-moss	93	Dio.	EN	WCA	83	CP	4	RS, GS	B3
M	<i>Didymodon glaucus</i> Glaucous Beard-moss	94	Dio.	CR	–	73	C	2	RS, SO	H3
M	<i>Ditrichum cornubicum</i> Cornish Path-moss	96	Dio.	EN	BAP/WCA	71	C	2	SO	J3
M	<i>Ditrichum subulatum</i> Awl-leaved Ditrichum	99	Mon.	VU	BAP	91	C	2	SR, SO	B3, H3, H5
L	<i>Dumortiera hirsuta</i> Dumortier's Liverwort	100	Mon/ Dio	VU	BAP	81	LS	5	RH, RS, SO	C3, H2
M	<i>Ephemerum cohaerens</i> Clustered Earth-moss	103	Mon.	EN	BAP	73	AS	5	SO	C3
M	<i>Eurhynchiastrum pulchellum</i> Elegant Feather-moss	104	Dio.	EN	BAP	26	PS	2	SO	H3, H5
M	<i>Fissidens curvatus</i> Portuguese Pocket-moss	106	Dio.	EN	BAP	91	C	4	SR, SO	FA, H5
M	<i>Fissidens serrulatus</i> Large Atlantic Pocket-moss	107	Dio.	VU	BAP	91	PS	3	RH, SO, GS	B2, C2, C3
M	<i>Grimmia anodon</i> Toothless Grimmia	109	Mon.	CR	–	66	PS	1	RH, RW	H3, J2
M	<i>Grimmia elongata</i> Brown Grimmia	111	Dio.	VU	BAP	16	PS	2	RH	H3
M	<i>Homomallium incurvatum</i> Incurved Feather-moss	113	Mon.	VU	BAP	45	C	4	RH, RW, SO	H3, J2
L	<i>Jamesoniella undulifolia</i> Marsh Flapwort	115	Dio.	VU	BAP/WCA	23	C	2	BR	G1, H3
L	<i>Leiocolea rutheana</i> Norfolk Flapwort	117	Mon.	EN	BAP/WCA	26	PS	2	SO	D4
L	<i>Lejeunea mandonii</i> Atlantic Pouncewort	119	Mon.	EN	BAP	80	CP	2	RH, SR, SO, EN	B3, G1, H3, J2
L	<i>Liochlaena lanceolata</i> Long-leaved Flapwort	121	Mon.	CR	BAP	43	C	3	SR	G1, H3

Moss/Liverwort	Species/English name	Page	*Sexuality	IUCN British Red List category	Biodiversity Action Plan Wildlife & Countryside Act	*Floristic element	+Life-history	*Nitrogen value	*Substrate classes	*Level 2 EUNIS habitat classes
L	<i>Lophozia capitata</i> Large-celled Flapwort	123	Dio.	VU	BAP	73	CP	2	SO, GS, DV	E3, H5, J3
L	<i>Lophozia herzogiana</i> Herzog's Notchwort	125	Dio.	VU	–	72	CP	2	DV, BR	F4
L	<i>Marsupella profunda</i> Western Rustwort	127	Mon.	VU	BAP/WCA	81	C	1	RS, SO	J3
M	<i>Micromitrium tenerum</i> Millimetre Moss	129	Mon.	EN	BAP/WCA	72	E	5	SO	C3
M	<i>Mielichhoferia elongata</i> Elongate Copper-moss	131	Dio.	VU	–	42	PS	1	RS	H3
L	<i>Nardia insecta</i> Bug Flapwort	133	Mon.	VU	–	43	LS	1	SO	H5
M	<i>Orthodontium gracile</i> Slender Thread-moss	135	Mon.	VU	BAP	81	C	2	RH, RS	G1
M	<i>Orthotrichum pallens</i> Pale Bristle-moss	137	Mon.	EN	BAP	53	CP	4	EW	FA
M	<i>Orthotrichum pumilum</i> Dwarf Bristle-moss	139	Mon.	EN	BAP	73	C	4	EW	E7, G1
M	<i>Philonotis marchica</i> Bog Apple-moss	141	Dio.	EN	BAP	83	LS	5	RS, SO	B3, H3
M	<i>Physcomitrium euryostomum</i> Norfolk Bladder-moss	143	Mon.	EN	BAP	75	E	7	SO	C3
L	<i>Plagiochila norvegica</i> Bilobed Featherwort	145	?	VU	–	52	PS	4	RH	G1
M	<i>Plasteurhynchium meridionale</i> Portland Feather-moss	147	Dio.	VU	–	91	PS	2	RH, SO	B3, H5, J3
M	<i>Pseudocalliergon turgescens</i> Turgid Scorpion-moss	148	Dio.	VU	WCA	16	PS	2	SO	D2
M	<i>Rhynchostegium rotundifolium</i> Round-leaved Feather-moss	150	Mon.	CR	BAP/WCA	73	PS	5	RH, RW, EW	FA, J2
L	<i>Riccia bifurca</i> Lizard Crystalwort	153	Mon.	EN	BAP/WCA	83	AS	3	SO	B3, F4, H5
L	<i>Riccia canaliculata</i> Channelled Crystalwort	154	Mon.	VU	BAP	73	AS	5	SO	C3
L	<i>Riccia nigrella</i> Black Crystalwort	156	Mon.	EN	BAP	91	AS	3	SR, SO	B3, H5, J2
L	<i>Scapania praetervisa</i> Ciliate Earwort	206	Dio.	VU	–	26	C	2	SR	H3
M	<i>Scopelophila cataractae</i> Tongue-leaved Copper-moss	157	Dio.	VU	BAP	86	PS	1	SO	J3
M	<i>Seligeria brevifolia</i> Short Rock-bristle	159	Mon.	VU	–	44	C	2	RH, RS	H3
M	<i>Seligeria carniolica</i> Water Rock-bristle	160	Mon.	CR	BAP	42	SS	2	RS	H3

Moss/Liverwort	Species/English name	Page	*Sexuality	IUCN British Red List category	Biodiversity Action Plan Wildlife & Countryside Act	*Floristic element	+Life-history	*Nitrogen value	*Substrate classes	*Level 2 EUNIS habitat classes
M	<i>Seligeria diversifolia</i> Long Rock-bristle	162	Mon.	VU	–	46	C	2	RH	H3
L	<i>Solenostoma caespiticium</i> Delicate Flapwort	163	Dio.	VU	–	43	CP	3	SO	C3, H5, J3
L	<i>Southbya nigrella</i> Blackwort	165	Mon.	VU	BAP/WCA	91	CP	2	RH, RS, SR	B3, H3
L	<i>Southbya tophacea</i> Green Blackwort	167	Dio.	VU	–	91	C	2	RS, RW, SR, SO, GS	B1, B3, D4, E1, J2, J3
M	<i>Sphagnum balticum</i> Baltic Bog-moss	168	Dio.	EN	BAP/WCA	26	LS	1	PT	D1
M	<i>Splachnum vasculosum</i> Rugged Collar-moss	170	Dio.	VU	BAP	16	SS	6	DA	D2
L	<i>Telaranea europaea</i> Irish Threadwort	172	Mon.	EN	BAP	80	C	2	SO, PT	F3, G1 I2
L	<i>Telaranea murphyae</i> Murphy's Threadwort	174	Dio.	VU	–	71	C	2	SO, PT	F3, G3, I2
M	<i>Thamnobryum angustifolium</i> Derbyshire Feather-moss	175	Dio.	EN	BAP/WCA	71	PS	4	RH	C3
M	<i>Thamnobryum cataractarum</i> Yorkshire Feather-moss	178	?	EN	BAP	71	PS	5	RH	C2
M	<i>Timmia megapolitana</i> Indian-feather Moss	179	Mon.	VU	–	76	C	6	EW	F9
M	<i>Tomentypnum nitens</i> Woolly Feather-moss	181	Dio.	VU	–	26	PS	2	SO, PT	D2, D4
M	<i>Tortula cernua</i> Flamingo-moss	183	Mon.	EN	BAP/WCA	46	SS	6	SO	J3
M	<i>Tortula cuneifolia</i> Wedge-leaved Screw-moss	185	Mon.	EN	BAP	91	C	4	RS, SR	B3, J3
M	<i>Tortula solmsii</i> Solms's Screw-moss	186	Dio.	VU	–	91	C	4	RS, RW, SR, SO	B3, H5, J2
M	<i>Tortula vahlana</i> Chalk Screw-moss	188	Mon.	VU	BAP	91	PC	5	SO	FA, J3
M	<i>Tortula wilsonii</i> Wilson's Pottia	190	Mon.	VU	BAP	91	AS	4	SR, SO	B3, FA, H5
M	<i>Weissia levieri</i> Levier's Beardless-moss	191	Mon.	EN	BAP	91	SS	1	SR, SO	B3, E1
M	<i>Weissia multicapsularis</i> Many-fruited Beardless-moss	192	Mon.	CR	BAP	71	C	4	SR, SO	B3, FA, G1R, H5, J3
M	<i>Zygodon forsteri</i> Knothole Yoke-moss	194	Mon.	EN	BAP/WCA	82	C	4	EW	G1
M	<i>Zygodon gracilis</i> Slender Yoke-moss	197	Dio.	EN	BAP/WCA	73	C	2	RH	H3, J2

Glossary

Acrocarp (acrocarpous)	producing female sex organs and sporophyte at the tip of main stems; stems mostly erect
Acrotelm	the upper layer of peat in an undisturbed peat bog exposed to fluctuating water table hence experiencing aerobic and anaerobic conditions over time
Alvar	limestone pavement
Antheridium (antheridia)	male sex organs
Apex (apices)	the tip or summit of a structure such as the stem
Apophysis	the sterile basal neck region of a capsule
Appressed	held flat or pressed against the stem or substrate
Archegonium (archegonia)	female sex organs
Asexual	reproduction without sex or fusion of egg and sperm
Attenuate	gradually tapering to a narrow point
Axenic	a culture of an organism that is completely free from contaminating organisms
Axil	the angle between a leaf and the stem
Basal lamina	the bottom part of a leaf
Biomass	in ecology, the mass of living organisms in a given area at any given time
Biotope	an area of uniform environmental conditions providing living space to a biological community of plants and animals
Bulbil	a small deciduous vegetative propagule , bud-like and green
Calcicole	a plant that thrives in lime-rich soil such as chalk or limestone
Calyptra (calyptrae)	a membranous cap or hood that protects the developing sporophyte and ultimately sits atop the capsule in mosses
Capitulum (capitula)	the mass of crowded branches at the stem apex in some mosses such as <i>Sphagnum</i>
Capsule	the structure that contains the spores
Ciliate	having fine hairs on the margin or surface
Circumneutral	nearly neutral, not acid or alkaline
Cleistocarpous	a capsule that releases spores by the decay or breakdown of its wall
Colonist	an early settler of a substrate (secondary succession), typically living for a few years but then disappearing (<i>cf.</i> pioneer)
Columella	a central column of sterile tissue within the capsule
Crenulate	having small rounded teeth or scallops around the edge (of a leaf)
Cryopreservation	process where cells or tissues are preserved by cooling to sub-zero temperatures, typically in liquid nitrogen
Cuticular (wax)	a water-repellent waxy coating on a leaf surface or other structure
Decorticated	bark or outer layer (of tree) removed
Decurrent	of leaf margins that extend below the leaf's insertion forming a ridge or wing on the stem
Diaphanous	translucent, delicate, allowing light through

Diaspore	any structure by which a plant can reproduce itself, such as spores , gemmae and tubers
Dioicous	male and female sex organs on separate plants (opposite of monoicous)
Diploid	a cell containing two complete sets of chromosomes
Electrophoretic mobility	motion of dispersed particles relative to a fluid under the influence of an electric field
Endemic	a species restricted to a single country or floristic area
Endogenous	originating from within the organism, tissue or cell
Epiphyte	growing on another plant but not parasitizing it
Excurrent	a nerve or midrib extending beyond the tip of the leaf
Fascicle	a bundle of branches
Filamentous	thread-like
Flagelliform	long and tapering, whip-like
Foliar gemmae	vegetative propagules formed on a leaf or in axils
Gametangia	sex organs on gametophyte producing sperm and egg
Gametophyte	the mostly long-lived green leafy generation at maturity producing sex organs
Gemma (gemmae)	vegetative propagules consisting of a few cells
Germplasm	a collection of the living genetic resource (of bryophytes)
Haploid	a cell containing one complete set of chromosomes
Humic	humus soil with organic matter resulting from decomposition of organisms
Inflorescence	a cluster of sex organs together with any specialized leaves that surround them
Isostatic rebound	the rise of land masses formerly depressed by the great weight of ice-sheets during the last glacial period
Lamella (lamellae)	narrow ridge of tissue running length-wise down leaves of some mosses
Lignin	a complex organic chemical compound found in the walls of plants giving structural support
Lithosol	a thin layer of soil consisting of un-weathered or partially weathered rock fragments
Mammilla (mammillae)	a bulge or rounded projection in a uniformly thickened wall (<i>cf.</i> papilla)
Meiosis	a special type of cell division necessary for sexual reproduction resulting in four daughter cells each with a haploid number of chromosomes
Metapopulation	a group of spatially separated populations of the same species, which interact through immigration and emigration
Mitosis	the process by which a cell divides, separating its chromosomes into two identical sets
Mitriform (or mitrate)	shaped like a bishop's cap
Moniliform	resembling a string of beads
Monoicous	male and female sex organs on the same plant (opposite of dioicous)
Motile	capable of moving or self-propelling

Multistratose	several to many layers of cells thick, of a leaf and other structures
Oligotrophic	poor in nutrients
Ombrotrophic	soil or vegetation that receives all of their water and nutrients from precipitation
Ovoid	egg-shaped
Papillae	a wart-like bulge or rounded projection formed from unequal thickening of the cell wall
Perennate (perennation)	surviving from one growing season to another, often with reduced or absent growth between seasons
Perennial	a plant that lives for more than two (many) years
Perianth	a tube-shaped structure that surrounds the developing sporophyte in liverworts
Pioneer	the first species to occupy a new habitat (primary succession)
Peristome	a circle of teeth surrounding the mouth or opening of a moss capsule regulating spore release
Pleurocarp (pleurocarpous)	producing female sex organs on short side branches, stems are mostly creeping
Poikilohydric life-style	ability of bryophytes to dry out, suspend metabolism and then resume physiological activity when water becomes available
Propagules	any part of a plant that reproduces itself by non-sexual (vegetative) means
Protonema (protonemata, protonematal)	the juvenile stage of a bryophyte, usually thread like, which develop into the leafy gametophyte
Rhizoidal tuber	tubers formed on rhizoids
Rhizoids	hair-like filaments that anchor the bryophyte to its substrate
Rosette	thalli radiating from a common centre
Saxicolous	growing on rocks
Secund	strongly turned or bent toward one side
Seta (setae)	the stalk of a liverwort or moss sporophyte
Sigmoid	'S'-shaped
Siliceous	soils derived from sedimentary rock rich in silica and acid in nature
Spermatozoid	a motile male gamete, or sperm
Spore	a one celled, usually haploid , reproductive structure that germinates to produce protonema
Sporophyte	the usually short-lived spore producing generation of a bryophyte comprising the seta and capsule
Struma (strumose)	a bulge or swelling on one side of the base of a structure, such as a capsule
Thallose (thalloid)	a flat plate or sheet of tissue not differentiated into leaves
Thallus (thalli)	a flat body of plant tissue
Tomentum	a dense woolly covering of rhizoids on the stems of some mosses
Totipotency	the ability of a fragment of any part of plant to grow into a new plant
Tuber	a lipid-packed vegetative propagule usually attached to a rhizoid
Tufa	limey deposits precipitated out in water through the process of respiration in mosses

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Acknowledgements

During the course of the year that it took to put this book together I have been helped by many people generous with both their knowledge and time. Members of the BBS, County Recorders and local naturalists have been unwaveringly helpful and patient with my constant enquiries. Some even undertook field visits to check on species that I had enquired after. Since the early 1990s, a small but devoted group of bryologists have been undertaking survey and assessment of rare species, initially under English Nature's Species Recovery Programme and latterly the UK BAP programme; their role has been especially important, not only in providing up-to-date information for this book but, more significantly, in the frontline conservation of England's bryoflora. Bryologists, past and present, have contributed to the development of an invaluable national database that is at the core of the conservation and Red Listing process and is available on-line through the NBN. To all I am most grateful.

I wish to acknowledge the BBS Conservation and Recording Committee who gave permission to use unpublished distribution maps ahead of the impending new Atlases of British and Irish bryophytes. I am especially indebted to Chris Preston who organised the distribution maps, provided summary information of numbers of bryophytes from the national database, traced information on past bryologists and responded to some no doubt exasperating enquiries and requests, and to Stephanie Rorke (nee Ames) and Colin Harrower at CEH for doing the computer work and producing the maps. Mark Hill also clarified several enquires relating to records and data from the immensely useful BRYOATT database. I am particularly grateful to David Holyoak and Nick Hodgetts for their generosity with rare species data and their help in many other ways.

Many people have generously allowed me to use their photographs and each picture is individually credited. I would however especially like to acknowledge Des Callaghan and Štěpán Koval who between them have provided so many excellent bryophyte images for this book. And in my endless requests for literature, Irene Bisang and Lars Hedenäs dependably delivered and I am immensely grateful to them both.

I am most grateful to many others who have responded to my requests for information including Jeff Bates, David Bell, Rienk Jan Bijlsma, John Blackburn, Tom Blockeel, Sam Bosanquet, Uwe Drehwald, Richard Fisk, Jan Hendy, Peter Howarth, Vincent Hugonnot, Mark Lawley, David Long, Peter Martin, Howard Matcham, Juana Maria Gonzalez Mancebo, Colin Pope, Margaret Ramsay, Lucy Reed, Gordon Rothero, Fred Rumsey, Neil Sanderson, Norbet Schnyder, Rod & Vanessa Stern, Robin Stevenson and Caroline Uff. Thanks are due to Apollo Books and Jean Paton for permission to use the illustration of *Lophozia herzogiana* from her book, and to Juan Guerra Montes for permission to reproduce the illustration of *Acaulon mediterraneum* from Vol. 3 of Flora Briofítica Ibérica. The on-line forum for the discussion for the discussion of bryology, operated by the International Association of Bryologists, has been extremely useful and I thank all the people that have given their advice and help via Bryonet.

Finally I would like to thank the **WILD**Guides team, in particular Robert Still and Andy and Gill Swash for their invaluable assistance and for dealing with so many last minute changes, and finally sincere thanks to Jill Sutcliffe for her editorial guidance and encouragement throughout, making it possible for me to write this book from my new habitat in Portugal.

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This index includes the English and *scientific* names of all the Red Listed mosses and liverworts covered in this book, as well as the species that have were once found in England but have not been recorded since 1980.

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